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PURE AND APPLIED SCIENCE[1]

By Professor CECIL H. DESCH

UNIVERSITY OF SHEFFIELD, NON-RESIDENT LECTURER IN CHEMISTRY AT CORNELL UNIVERSITY UNDER THE GEORGE FISHER BAKER FOUNDATION

IN entering on the duties of the George Fisher Baker lectureship in Cornell University, I must first express my high appreciation of the great honor done to me by the university by its invitation, and of the great personal kindness and helpfulness of Professor Dennis in all matters concerning it.

Only a short time ago Mr. Baker, to whom this university owes so much, passed away, full of years and honor. Education in America has been singularly fortunate in attracting the support of many wealthy leaders of commerce and industry, and the results are to be seen in such magnificent buildings as this in which we meet, and in the facilities given for the interchange of students and teachers between different institutions and different countries. The visiting lectureship which George Fisher Baker founded in this university has been the means of bringing a number of European workers in various branches of science related to chemistry to Cornell and has given to them an unrivaled opportunity of seeing American university conditions at their best and of exchanging ideas with a new and keen group of students and colleagues.

With the possible exception of music, no form of human activity is so independent of national barriers as scientific research, and every step that brings into closer connection the scientific workers of different countries deserves a warm welcome. Judging by the enthusiasm and the affection with which my predecessors in this lectureship have spoken to me of their stay at Cornell, this scheme, which we owe on the one hand to Mr. Baker and on the other to Professor Dennis, must rank high among such efforts at international cooperation.

Previous lecturers have dealt with different branches of pure chemistry and of sciences allied to it, but I believe that I am the first whose teaching duties are definitely concerned with the application of science to industry, and I ask you to allow me to consider in

[1] Introductory public lecture.

this opening address some aspects of the relations between pure and applied science.

As I left London, scientific men of many countries were assembled there to do honor to the memory of Michael Faraday, the occasion being the centenary of his discovery of electromagnetic induction. From that discovery has grown the whole of the modern electrical industry, for without it there would be no electric generators or motors, no radio-transmission, no generation of current except on the smallest scale. At the Faraday exhibition now open in London, the statue of the discoverer occupies the center of the large circular hall, and is surrounded by cases containing the apparatus used in his early experiments. From each of these extends a sector, illustrating the developments in electrical science and practice which may be considered to owe its origin to those experiments. Yet Faraday was an "experimental philosopher," one whose sole aim was to learn something of the workings of nature. He had in mind no practical application of his discoveries, and never concerned himself with the invention of machines. He was even skeptical of the possibility of using electromagnetic methods in place of the primary battery. His work was guided throughout by the purely theoretical conviction of the unity of natural forces, which led him to seek for the connection between electricity, magnetism, light, chemical action, and even, although at the time without success, owing to the minuteness of the effect, which was afterwards found in our own day, with gravitation.

It was not from any contempt for practical objects that Faraday confined himself to work in pure science. He was always ready to assist the state and public bodies by his advice when it was invited, notably in his work for Trinity House, the authority which in England controls the lighthouses on our coasts. At the same time, caring nothing for wealth, he refused to be tempted by the offer of large sums to enter industry and to devote his genius to immediate practical objects. Little as he would have expected it, industry has gained enormously by his decision to investigate fundamental principles. He actually produced, in the course of his experiments, the first dynamo-electric machine—a copper disk rotating between the poles of a magnet and supplying continuous current to a pair of brushes in contact with it—but he took no part in its development, although within a very few years machines based on his principles were constructed and brought into practical use by others.

The complexity of modern science, and the large number of workers in almost every field, make it unlikely that future Faradays will be able to open up a new region with the same completeness, but it remains true that practical inventions mostly arise as the unforeseen by-products of studies which had as their aim the discovery of relations between the phenomena of nature.

There has lately been presented to us an entirely different view of the relations between pure and applied science. A striking incident at the International Congress of the History of Science held in London this summer was the appearance of a number of scientific delegates from Soviet Russia, prepared with papers which were immediately published with the title of "Science at the Cross-Roads." In these papers the thesis was maintained that scientific research carried out for the satisfaction of intellectual curiosity is anti-social, and that henceforth research must be directed towards some practical end, having direct value for the community. This is not to say that science is to be confined to mere technology—the distinction attained by some of the speakers in their own fields of science would make such a statement a caricature of their views—but the possibilities of application are to be kept in mind throughout. This view of the science of the future, although taken, with the other principles of the Soviet system, from Karl Marx, had been maintained earlier by Auguste Comte, who held that the need for knowledge in certain fields of importance to society was so imperative that it was the duty of men of science to concentrate, at least for a generation or two, on the solution of a few problems, to the exclusion of researches dictated only by curiosity, of however high an intellectual order. Comte did not foresee the great unification of science, beginning with the doctrine of the conservation of energy, that was in progress during the later years of his life, and Marx, a much less profound thinker, was so obsessed by the purely economic problem as to fail to understand the real meaning of science.

The Soviet theory claims an historical basis. It is argued that all scientific research had its origin in practical needs. This is true of the first beginnings of science. The study of the stars was a necessity of pastoral races to guide their wanderings, and geometry, as its name signifies, was originally land surveying, necessary to the settled agriculturalists. But after these beginnings science took its own course. Astronomy and mathematics were studied for the new knowledge they gave, without care for possible applications. Plato's conception of pure science, which would limit its scope to the most abstract part of the mathematical sciences, was that of a philosopher and not of an experimental investigator, but it would be absurd to say that it was anti-social. Ever since the foundations of abstract science were laid by the Greeks, men have felt, instinctively or on the ground of a definite theory of life, that the disinterested search for knowledge was good in itself, and worthy of the best human effort.

Suppose, however, that we admit for the moment that the desire to satisfy intellectual curiosity is a selfish one, and that the world needs an answer to many problems that affect the welfare of mankind, does it follow that scientific research should be confined to those problems with the object of obtaining, by combined effort, the most speedy result? Experience teaches the contrary. The history of the transmission of messages by electric waves has often been told, but it would be hard to find a more striking illustration. Eighty years ago the electric telegraph was well known and understood. Let us suppose that electrical engineers had been asked to discover a method which would dispense with the wire or wires connecting the sending and the receiving stations. The supposition is absurd, for there was nothing in the known properties of the electric current to suggest such a possibility, but it is safe to say that if a team of workers trained in telegraphy had been instructed to find such a method they would have met with no success, even after years of combined effort. The actual history of the solution is very different. Faraday, who had no mathematical training and never used a mathematical symbol, nevertheless stated his conception of the electro-magnetic field in such a way that Clerk Maxwell was able to give it mathematical shape and to deduce the formal equations from which it followed that changes in electric or magnetic force must be propagated as waves. This was verified in 1888, nearly ten years after Maxwell's death, by the brilliant experiments of Heinrich Hertz. Electric waves had actually been observed earlier by Joseph Henry at Princeton, but the observation had not been followed up. Transmission over a distance of a few feet having once been achieved, the later development of wireless telegraphy and telephony, extraordinary as it is, has been mainly in the application of known principles by skilful engineers and inventors. The greatest single step in that advance, the invention of the thermionic valve or tube, which has made modern radio-transmission possible, arose from investigations of the emission of electrons from heated solids, investigations which appeared at the time when they were undertaken to be as remote as possible from any practical application. As the uses of the original invention multiply, and as greater and greater refinements of technique are required, the discoveries of pure physics in the most varied branches are pressed into service. The photo-electric properties of certain elements and compounds, the variation of the electric properties of quartz crystals with changes of pressure, and the action of organic liquids on the plane of polarization of light, are examples of such phenomena. All of them were discovered in the course of pure research in physics, without thought of practical use, and again illustrate the fact that important inventions are in the main the by-products, rather than the intended results of scientific research.

In an interesting address delivered to the Society of Chemical Industry in 1928, Dr. Irving Langmuir described how experiments, at first intended to improve the vacuum in incandescent lamps, led him into research on the liberation of gases from heated bodies, with results of great interest for pure science. The enlightened policy of Dr. Whitney and the General Electric Company made it possible for him to pursue this line of research, although it seemed unlikely to lead to any results of practical use. In the end, it led to the gas-filled lamp, an invention of very high value, but quite different from the original object of the research. It is in America particularly that great corporations, which possess exceptional facilities for research, such as the laboratories of the General Electric Company at Schenectady and those of the Bell Telephone Company at New York, have taken such a broad view of their functions as to allow members of their staffs showing great experimental ability to follow an interesting line of investigation even though it might appear to have no immediate practical object.

I must not be unfair to the Soviet delegates. They would readily admit that results of value may be reached by indirect means, but would claim that the investigator must always have utility in view, and must not regard himself as free to follow any interesting line of study that may happen to appeal to him. For the spontaneous activity of individual workers they would substitute the organized labor of skilled teams.

A feature of the Marxian theory of science is its virtual denial of the importance of genius. It will be found that every great discoverer has had precursors and contemporaries in the same field. Oersted, Ampère and Arago had discovered important relations between electric and magnetic effects before Faraday, whilst Joseph Henry independently made the same observation of electro-magnetic induction. The subject was engaging attention, and it is easy to argue that if Faraday or Newton had never lived the discoveries that we associate with their names would have been made by others without very much delay. In that there is an element of truth. Since the picture of the universe which science constructs becomes one that is accepted as true by all those who have the training necessary to appreciate it, we are bound to believe that those regularities which we call laws will be discovered in course of time. But the progress of discovery is enormously hastened by the advent of a man of genius. Ostwald's comparison of the genius with a catalyst is a good one. The catalyst does not alter the final state of a chemical reaction, but it may very greatly accelerate it. No one can examine the

writings of Newton or Faraday without feeling that the transformation of science brought about by their work was of an entirely different order from that of even their most gifted contemporaries and that the pace of scientific discovery was almost immeasurably quickened in consequence. It is not an isolated experiment or series of experiments by Faraday that is now being commemorated, but a conception of the electromagnetic field based on those experiments, so perfect that it has been adopted by all later students. We can only regard it as a work of genius. It would be absurd to imagine that, if Shakespeare had never lived, "Hamlet" would sooner or later have been written by another hand or, if the task had proved too great for one man, then by a duly appointed team of writers. Scientific discovery is not strictly parallel with literary creation, but sufficiently so to make us conscious of the essential services of genius in that field also.

In the subsequent lectures of this course there will often be occasion to refer to the use of the microscope in the examination of minerals and metals. We owe these methods to a Sheffield amateur, Henry Clifton Sorby, who fully deserves to rank as a genius, although on a lower plane than Faraday. Free from all duties of teaching or administration, Sorby devoted himself to independent research in science, studying rocks, strata, meteorites, steel, plants, animals and archeological remains with that insatiable curiosity which marks the born discoverer. In every field he added new knowledge, but he is the undoubted founder of two branches of study, microscopical petrology and metallography, both of which have grown to great dimensions, and have proved essential tools in both pure and applied science. In a plea for "Unencumbered Research," published in 1876, Sorby urged that the research worker should be left entirely free to choose his path, with the assurance that the real investigator, if we can find some way of recognizing him when young, before he has been forced into a mould, will produce the best results if left unfettered.

This is not to belittle the team work which is so necessary in the application of scientific results to industry, agriculture, medicine or other practical ends. Those activities depend on science to an extent undreamed of in Sorby's time, and our great laboratories of applied science call for increasing numbers of research workers trained in pure physics, chemistry and biology, in addition to those whose education has been given a special technical bent. But we must have in the universities groups of "unencumbered" workers free to choose their own line of research and pursuing it for the love of scientific discovery alone, or the organized team work will before long flag and languish from lack of inspiration.

The art of smelting metals is an ancient one, and until the eighteenth century it was almost entirely empirical. The trade of the smith, in all its varieties of form, was one of the most rigidly preserved of crafts, since its success depended so entirely on the traditional skill of the craftsman. A few men of scientific insight, such as the German Agricola in the sixteenth century, had sought to reduce the knowledge of the art of smelting to some order, and to free it from the grosser errors and superstitions, but it was a few chemists of the eighteenth century, notably Réaumur in France and Swedenborg in Sweden, who made intensive studies of certain branches of metallurgy and sought to place them on a scientific basis. Their writings are of interest to us to-day. Nevertheless, the empirical character of the art persisted, and truly scientific metallurgy is of quite recent date. The influence upon it of researches in pure science is perhaps best seen by considering, not the smelting of metals from their ores, but their treatment to give useful products. In the steel industry, so long as cast and wrought iron and such steels as those used for cutlery were the only known materials, empirical methods answered well enough, but with the expansion of the industry brought about by the invention of new steel-making processes it became necessary to consider, for instance, the effects of carbon in modifying the properties of iron. The physical chemist was called in, and the first draft of the iron-carbon equilibrium diagram by Bakhuis Roozeboom in 1900 marks the beginning of a new era. About the same time, Heycock and Neville carried out an investigation of the alloys of copper and tin, using microscopical and thermal methods, and setting a standard of accuracy which profoundly influenced later work. It was now seen that changes may proceed in solid metals in such a way that, without any alteration in chemical composition, materials of entirely different properties may be obtained by varying the rate of cooling. The hardening of steel by quenching in water, in use for more than 3,000 years, is only one of many such processes which are employed in metallurgy. Gradually, the microscope and the thermo-electric pyrometer have come to be essential tools in metallurgy, and micrographic analysis supplements chemical analysis in all works laboratories.

Besides undergoing thermal treatment, metals and alloys are subjected to mechanical processes, such as rolling and wire-drawing, which profoundly modify their properties. Empirical knowledge and skill have done much for the perfection of those processes, but it has been found that they can not be utilized to the best advantage without an understanding of the internal mechanism of the change. Metals are made up of crystals, so the metallurgist has called to his aid the work of the crystallographer. Whilst the older geo-

metrical crystallography could only indicate in a general way the nature of the changes during deformation, the newer study of crystals by means of their x-ray diffraction patterns throws a flood of light on the process. In consequence, the x-ray tube is taking its place with the chemical balance, the microscope and the pyrometer as one of the essential tools of the metallurgist. There are others. Many metals are greatly influenced by the presence of very minute quantities of impurities, sometimes so small that chemical detection is difficult or impossible. Here the quartz spectrograph, capable of following the spark or arc spectrum into the ultra-violet, renders great service, and is rapidly making its way into manufacturing plants as well as into research laboratories as a standard means of control. Magnetic measurements afford another means of studying the composition and internal condition of metals, so that we find, in some large steel plants, the estimation of the quantity of carbon dissolved in the bath of a large open-hearth furnace carried out by casting a small specimen and determining its magnetic properties, the method being accurate and at the same time simpler than a chemical analysis. In another class of manufacturing operations, magnetic measurements are used as a means of deciding whether steel objects, made in large quantities, have received the proper heat treatment, where formerly a number of objects from each batch had to be tested mechanically to destruction in order to obtain the information now gained at a fraction of the original cost. All these methods of testing have been adopted from the laboratories of pure science and have been turned to new uses. It is thus one of the services of pure science that it furnishes applied science with new tools of research and means of measurement. On the other hand, the increasing demand on the part of the workers in applied science for such tools acts as a continual stimulus to investigations in physics.

Some metals, notably tungsten, have in our own time passed from the state of chemical curiosities to that of important technical products, by methods which are essentially those of the physical research laboratory. No one can visit one of the great lamp or radio-tube works without feeling that the manufacturing department is essentially an enlarged laboratory, employing methods which only a few years ago were confined to the research worker. We have the paradoxical result that the physical constants of tungsten are known with much greater accuracy than those of the more common metals, whilst of the metal, iron, manufactured by hundreds of millions of tons, the data as to its properties in a pure condition are singularly imperfect.

An example of the changing character of applied science may be seen in the study of corrosion. The most important of our useful metals, iron, steel, copper, brass, aluminum and so on, are all liable to undergo corrosion, to an extent which involves colossal annual losses. Protective methods have been devised empirically, but of late years much has been done to develop the use of metals which are in a sense self-protecting, in that they quickly form a layer, probably only a few atoms thick, which resists chemical attack. The "stainless" steels belong to this category. Looked at theoretically, this form of protection may be traced back to the work of Faraday and Schoenbein on the passivity of iron, although the connection was not at first recognized. It is important for the manufacturer and the user to have some means of determining in advance how a given metal will behave under given conditions of exposure to corroding agents. With this object, many hundreds of thousands of tests have been carried out in scores of laboratories, every effort being made to obtain a standard test, but the results have been singularly disappointing. There is no form of rapid test which will indicate with certainty how a metal will behave when it is exposed for periods of years. Such empirical and *ad hoc* methods are now supplemented by studies of the fundamental nature of corrosion. The methods of the physical chemist have been adopted, and laboratories devoted to work on corrosion now combine measurements of the absorption of oxygen with those of electrolytic potential and of the microscopical examination of the formation and rupture of surface films. In this way an intimate knowledge of the process of corrosion is being gained, by the help of which the choice of resistant materials may be guided in the future with greater certainty.

In its turn, applied science reacts on pure science. The problems raised by the working of metals, for instance, have given a great stimulus to the study of the deformation of crystals, with a corresponding effect on molecular theory. Moreover, the needs of the technical laboratory and works lead to the construction of instruments of measurement which are continually improved for practical use, and are in turn adopted by the research workers in physics and chemistry. Such mutual influence counts for much in the advance of science. To turn now to another aspect of the subject.

That we can not fully appreciate a scientific principle or discovery without some study of its history is a truth more and more vividly realized by those whose business it is to teach science to students. A knowledge of the steps by which a scientific doctrine has been built up or an invention brought to perfection is necessary if we are to estimate aright its value and importance. As we must not undervalue the services of genius, so we must not, on the other hand, isolate a few famous discoverers and neglect their predecessors

and contemporaries. The study of the history of a science is now widely recognized as an integral part of a training in that science. It would be well if the same view were taken in the teaching of applied science and technology, and in this field it is not difficult to enlist the interest of students. Here is also one means of bridging the gulf, so deplorably wide in the highly specialized education of the present day, between scientific and humanistic studies. The history of an applied science or of an industry depending on it may be brought very simply into relation with the state of society at successive epochs. May I again illustrate this point by a few references to the study of metals? A short account of the history of the first use of metals by man may well open a course of lectures on general metallurgy. The first metal known was gold, since it is found in the beds of rivers in the uncombined state, resists tarnishing and by its gay color and luster appeals to the decorative instincts of Stone Age man. It is too soft to be used for any purpose but that of ornament. Copper follows, at first used as the native metal, but later obtained—no doubt in consequence of the accidental fusion of the conspicuous green surface ores in domestic fires—by smelting. These masses of copper, which can be cast in an open mould and can be so hardened by hammering as to take and keep a cutting edge, inaugurate the first Metal Age. The next step, the production of the much harder alloy, bronze, which may be cast in closed moulds, is an immense advance, and its origin is one of the unsolved mysteries of metallurgical history. Iron, sporadically used from quite early times in the form of objects forged from meteorites, is only smelted at a later period, but the steady supersession of bronze by iron is important and may be sketched. A simple account of these archeological facts, showing how the objects characteristic of each stage bear, in the earliest forms, clear traces of their origin in the copying of older objects in a new material, encourages an interest in the history of the older civilizations. The part played in the movements of races and in the history of nations by the search for metals is an important one, and recurs again and again, as in the events which followed the discovery of gold and silver in Central and South America by the Spaniards, and in the Californian and Australian gold rushes of the last century. Or, turning to iron and steel, it may be shown how the introduction of the steam engine, which brought about the industrial revolution by substituting machinery for hand labor, was itself made possible by metallurgical improvements, notably by the substitution of coke for charcoal in the blast furnace and by the invention of puddling. In the second half of the last century, the Bessemer process began that enormous increase in the rate of growth of the heavy industries which has been one of the chief features of the economic history of the world in our own time. When the university, as at Sheffield, is situated in a town having a metallurgical history possessing special features and extending over several centuries, local history may be linked up with the technical teaching.

These illustrations are introduced not for their practical importance, but because they widen the interest of the student, and encourage him to include in his private reading some study of the history of industrial communities. Such a study, if well pursued, may prove in the end to have practical value also in enabling those on whom the responsibility of directing and controlling industry may fall to understand better the social and economic conditions in which they have to work. Where a Social Survey is in progress, students of science and technology having some background of historical knowledge can be among the most useful voluntary workers.

In the teaching of the history of a pure science, stress is naturally laid on its value for the understanding of that science in itself, but in a balanced education it would seem that it should have a further value. The development of scientific thought is such an essential part of the history of civilization that it should be prominent in the teaching of general history, but this view only makes its way slowly.

There is another aspect of the relation of science to the community. The public conception of science is commonly limited to the mathematical, physical and chemical sciences, with the many departments of biology and their applications and in recent years, psychology. The great field of social studies is usually, at least in Europe, regarded as outside the field of science, with the single exception of economics. However, if prediction be the test of science, economics has not been, in the last few years, conspicuously successful.

It has been the aim of many thinkers to build up a science of human society, to embrace not only economics but all the activities of man. Sociology, to use the name coined originally by Comte, is the most difficult of the sciences, because it deals with phenomena of far greater complexity than any of the physical or biological sciences. Few of its principles have yet been established, and it must still be regarded as a science in the making, but its importance is such as to deserve the attention of all students, in spite of the urgent claims made on their time by their chosen specialism. I believe that this fact is more generally recognized in America than in Europe, but nowhere is the treatment of social problems, such as those of politics and finance, scientific to the extent that would be desired by the sociologist, and it would seem that those who already employ scientific methods

of reasoning with success in one field could render service in bringing about their extension to others.

Science, in its applications to technology, has made available to mankind forces incomparably more powerful than those of a few generations ago. The command over natural forces has so increased the scale of production that we appear to suffer from an excess rather than from a deficiency of products, agricultural as well as industrial. Yet, although the standard of life has risen, the community to-day is faced by problems as difficult and dangerous as at any time in the world's history, and the growth of industry has as yet by no means brought all the happiness that was once expected of it.

Moreover, the application of science to warfare has greatly increased its horror, and it is certain that in another war, if such should occur, all the resources of science would be pressed into service to increase that horror still further. The means furnished by science may be used for the great benefit of mankind or misused in such a way as to cause misery. Is it not, then, desirable that all who are concerned with the advance of science by research or with its application to practical uses should interest themselves in the difficult problem of its use for the benefit of mankind? In other words, must not the chemist or biologist seek to become, in however modest a way, a sociologist, seeing that he can not divest himself of responsibility for the uses to which science is put?

Here, again, applied science serves as a link. The progress of pure science occurs within a limited circle of specialists, and contact with the general public only becomes marked when some question having a popular appeal emerges, as in the present-day interest in astronomical speculations as to the structure and fate of the universe. On the other hand, the contacts between applied science and the community are perpetual, and every worker in such a field must have some consciousness of its social significance.

The fact that in science international barriers have disappeared, or are reduced now to the minor obstacles due to differences of language, makes it easier for the scientifically trained man than for another to appreciate what international conditions mean in the modern world. It is science that has speeded up communications by land, water and air, that has brought most countries within speaking distance of one another, and that has largely destroyed the strategic value of natural frontiers. In doing so it has solved some problems and created others. It has become clear that the natural resources of the world are not inexhaustible, and that unless steps be taken to conserve them by using them as efficiently as possible, our descendants will find them dangerously depleted within an easily calculable time. Those resources are of the nature of capital, and once consumed can not be renewed. It is far otherwise with the power derived from water or, as may be practicable in the near future, from the direct heat of the sun; with the annually renewable products of agriculture, or the analogous products, harvested at longer intervals, of forestry. A scientific view of the matter would stress the importance of making greater use of the second source of wealth, which has been, in most countries, so much subordinated to the former. I do not know how it may be in America, but in Europe our political leaders and our economic authorities are, in an overwhelming proportion, urban in outlook.

A great Scottish scientific teacher, Professor Patrick Geddes, has pointed out that there is not one Industrial Age, characteristic of the modern world, but that two may be distinguished. These he has called, borrowing an analogy from the archeology of the Stone Age, the Paleotechnic and the Neotechnic. In the first, of which the most conspicuous illustration is the condition of England in the generations following the invention of the steam engine, the discovery of means of accumulating riches faster than had been dreamed of before led to an enormous extension of industry, unplanned and without safeguards against its abuse. This meant the reckless exhaustion of coal and minerals, and in the earlier decades a callous disregard on the part of many industrialists of human health, comfort and safety. Evils grew up in the industrial regions which had to be fought by philanthropic effort and by legislation. Other nations followed suit at such a short interval that whilst some of the evils were avoided, yet on the whole an absence of planning for social benefit was as conspicuous as ever. Gradually, signs of a passage to the Neotechnic Age are becoming apparent. The more scientific use of fuel and the increasing replacement of the smoke and dirt of coal-fired furnaces by the bright cleanliness of electric heating marks the transition. A modern power station using water power may stand as a symbol of this age. The health and welfare of the workers become a first consideration. The conservation of natural resources, in minerals, forests and water is regarded as a national and an international duty. Intelligent planning takes the place of haphazard development for merely private advantage. Whatever may be the economic system of the future, it must surely involve such planning, with a recognition of duties that leaders of industry, whether private or public, owe to the community. Of the moral aspects of the transition, all-important as they are, this is not the occasion to speak.

It is naturally more difficult to maintain a strictly scientific attitude on questions of politics, social organization and finance than on those of atomic physics, since our personal interests are involved, but that

the attempt should be made is a conclusion which forces itself on a student of science who lives and works in an industrial community. Most of all, at such a time of crisis as this, does the need of scientific thought impress itself on us. By widening the conception of science to include sociology, whatever form that incipient science may take, it should be possible to increase very greatly the influence of systematic observation and reasoning, which is what we mean by science, on human life.

From the point of view of the general influence of science the recent tendency to lay emphasis on the uncertainty of scientific prediction in atomic physics is unfortunate. The "principle of uncertainty" is really a confession of ignorance, and it is to be expected that as the theoretical treatment of problems in the structure of matter advances, means will be found of reconciling the difficulties now experienced. It would be unfortunate if an impression were to gain ground among the public that science has abandoned its claim to accurate prediction. The cases in which prediction fails, according to the principle just mentioned, are confined to a difficult section of physical science which has only recently come under discussion. It would be entirely premature, on the strength of such new conclusions, to abandon the principle of determinism which has hitherto served its purpose so well in the sciences.

The inspiration of modern science must come from the original investigators, seeking for nothing but a more profound understanding of the workings of nature, and provided with the facilities for observation and experiment. Linked with them in the most intimate contact that the organization of university and industrial laboratories can make possible, come the workers in applied science, connected closely on the other hand with the technologists, charged with carrying into practice the results of scientific research. It is neither necessary nor possible to draw sharp dividing lines between those classes, but they may be broadly distinguished. All may unite in doing honor to great discoverers, such as Faraday, for all alike may trace their activities back to the products of their genius.

SCHAUDINN

A BIOGRAPHICAL APPRECIATION[1]

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WE are assembled to-night to memorialize a man, and an occasion. Let us begin with the man.

Fritz Schaudinn was born at Roeseningken, a village in East Prussia, on September 19, 1871. Thirty-five years later, on June 22, 1906, he died of septicemia and collapse at Hamburg. Into this short life-span he compressed activity and achievement that placed him in the ranks of genius.

Of his family and antecedents practically nothing appears in the accessible published sketches and eulogies. His gymnasium education was carried through at Insterburg and Gumbinnen. In 1890 he began his preparation for a career in philology, but by the fifth semester at the University of Berlin was definitely embarked on his life-work as a zoologist, and by his thesis for the doctorate in 1894 committed himself to parasitology, then the infant of the zoo-medical sciences. In July, 1894, from Bergen, Norway, and again in a trip to the Arctic in 1898, he gathered material, published subsequently with Roemer as junior, for a massive communication on the fauna of the region. In October, 1894, he had been appointed assistant in the Zoological Institute in Berlin, and in 1898 achieved his docentship. During this period appeared a number of papers on the reproductive processes in Protozoa, which broke new ground repeatedly and foreshadowed distinctive investigative powers. His contributions with Siedlecki on the Coccidia were especially valuable, and Schultz has rated the account of the complete life cycle of *Eumeria Schubergi*, which appeared in 1900, as an example of the ideal in research, in that it has been impossible since to add one single fact to the material discussed by Schaudinn. In 1899 his contacts with medical protozoology began, in the confirmation and amplification of Ross's observations on the malarial parasite. A mission for the German government, which kept him at Rovigno from 1901 to 1904 to study the pathogenic protozoa, led to his appointment as director of the new division of protozoology in the Imperial Public Health Service. At this time the insistent publicity given by Schulze to Siegel's supposed protozoal cause of syphilis, the *Cytorrhyctes luis*, led to a request made by Köhler, president of the Gesundheitsamt, that Lesser, the head of the Clinic of Dermatology and Syphilis at Berlin, cooperate in a joint clinical and parasitologic study of the prob-

[1] Read before the Section on Medical History of the College of Physicians of Philadelphia at a meeting to commemorate the discovery of the cause of syphilis, November 9, 1931.

lem. Schaudinn, who had already been in contact with Lesser and Hoffmann on the matter, was designated as the protozoologist, and Hoffmann was selected by Lesser as the syphilologist to pass upon and make histopathologic studies of the material submitted to Schaudinn for study. Neufeld and Gonder, Schaudinn's assistant, joined the investigation, the former to control the animal experimental phase. Schaudinn's pioneer work on spirilla, especially in the blood of birds, and his studies of the life cycles of *Halteridium* and *Leucocytozoon Ziemanni* made him the obvious leader of the group. Novy rates his acquaintance with extremely minute spiral organisms thus obtained as a principal factor in the extraordinary discovery which followed. In the *Halteridium* study, although directed at a miscue, Schaudinn had named and described the genus Spirochaetae, remarked on their extreme minuteness, expressed the belief that they might be filterable, and even went so far as to suggest that yellow fever might be caused by similar organisms.

In the late winter and early spring of 1905 the investigation got under way, with an admirable selection of material, limited to the most infective lesions. On March 3, Schaudinn, in the room devoted to the investigation in the women's clinic of the old Charité in Berlin, saw the *Spirochaeta pallida* in numbers in a fresh preparation made by Hoffmann from an eroded syphilitic vulvar papule, using a Zeiss apochromatic objective with ordinary illumination. He then demonstrated the specimen to E. Hoffmann and to Neufeld. Secretions from a pointed condyloma were found apparently in the same session or in one immediately following, to contain spirochetes likewise, but the morphologic differences between *Sp. refringens,* later so named by Schaudinn, and *Sp. pallida* seem never for a moment to have been in doubt in his mind, although the final demonstration of their disparateness required further study. The work carried through between this date and the preliminary note published by Schaudinn and Hoffmann, presented as a communication from the Kaiserliche Gesundheitsamt (April 10, 1905), included the demonstration of the organism both in the fresh and azureosin (Giemsa) stained specimens of fluid from both open and closed lesions and also from the pulp juices of the satellite lymph-nodes. In the film preparations Schaudinn had recognized but did not stress what he regarded as possible resting stages of the organism. This first communication closes with control studies of non-syphilitic conditions and lesions, and with citation of the observations of Berdal and Battialle on spirillar organisms in balanoposthitis circinata, of Csillag in the same condition, and of Rona on the occurrence of spirilla in genital lesions and in hospital gangrene and normal smegma. Metchnikoff, who with Roux had accomplished the first successful transfer of syphilis to the apes, was drawn into Schaudinn's studies by a letter dated May 2, 1905, and after a careful search succeeded in finding the organisms in the primary lesion of a *Macacus cynomolgus,* and subsequently in other apes, their identity being confirmed by Schaudinn. This was followed by Metchnikoff and Roux's announcement to the Paris Academy of Medicine on May 16. On May 17 Schaudinn and Hoffmann formally demonstrated their discovery to the Berlin Medical Society and the announcement to the medical public, with a fuller discussion of the differential morphology of the organisms concerned, together with Levaditi's confirmation from congenital syphilitic material, appeared in the *Berliner Klinische Wochenschrift.* The rapidity with which the discovery was taken up by the scientific world is illustrated by the collection recorded by Hoffmann, of 750 titles by the end of December, 1906.

In October, 1905, appeared Schaudinn's last publication, a masterly presentation of the spirochete problem in which he foreshadowed his interest in the life cycle and developmental studies which he was not to take up. The relation of the spirochetal organisms to trypanosomes and the possible life cycle transformations appear to have raised a controversy among protozoologists which the loss of Schaudinn's genius has left to a large extent unresolved.

On January 11, 1905, Schaudinn was called to the directorship of the Institute for Ship and Tropical Hygiene in Hamburg. This appointment was a welcome one, for it released him from the bureaucratic atmosphere and executive hack-work of the Gesundheitsamt, which threatened to subordinate his investigative capacity to minor ends, and assured him of unrestricted research opportunity. It carried with it a salary which would at once have lifted the burden of meager living which had rested on him and his family during his short working years. But the opportunity came too late. The perirectal infection which finally overcame him was already in progress. The journey to the International Medical Congress at Lisbon, undertaken in part in the hope of regaining health, had the opposite effect, and an emergency operation, followed by a period in the Eppendorf Hospital in Hamburg, terminated in a second operation, collapse and death. Three weeks after his death his third child, a younger son, was born.

Twenty-five years is not too short a time in which to begin to accumulate legend centering about a personality whose career has such unmistakable elements of the dramatic as this. It is perhaps a tribute to scientific detachment that the eulogies of Schaudinn

deal so largely with discussions of his scientific accomplishments, so little and in such general terms with the life history and make-up of the man, himself a biological phenomenon of no mean order. There appears to have been no family background of scholarly and intellectual achievement such as lies behind the Galtonian concepts of inherited ability. The single portrait that survives in the memorial literature, and a few scattered descriptive words, portray him as a physically massive but finely tooled personality, to which are applied the resonant and almost majestic German words, "gewaltigen, imposanten und kräftigen Gestalt." He evidently lived life in outflowing fashion, with robust humor, frankness at times almost too outspoken for his advantage among bureaucrats (witness a brush with Altdorf), and with an enthusiasm, a joyous and sparkling abandon mingled with his love of truth and work that earned the adjectives "schaumenden Lebenslust." His death shocked his friends into a silence in which they could scarcely grope for words to describe the qualities that endeared him to them. Yet he had the grace to make a few enemies. His extraordinary fairness and generosity, in the face of what might well have been and indeed was to others an incentive to small practice, appears in his full, meticulous recognition of his associates in the spirochete discovery. He was beloved of his pupils no doubt for this among other reasons. His closest friends were given a glimpse of the tenderness, the sensitiveness that lay behind this truly magnificent front. His family was the joy of his life, music his release, the piano his instrument to an unusual degree. Those phrases which so untranslatably express the best the German spirit sees in the personal life are freely applied to him—"Gemütigkeit, voll Anmut und Stimmung." He moved with directness upon the worthwhile objectives; bore no jealousies, was indifferent to the side-issues of form and manner that to so many obscure the substance of creative thought. It is easy to imagine, if this is the man, what genuine anguish must have seized those from whom he was taken on the eve of fulfilment.

But we are concerned, too, with the structure of his mind and body as an implement of research. Passing at thirty-five, he misses, perhaps, the reappraisals inevitable for those who live to later years, entering the shadow of the reflective, and vanishing in the mists of senility. He gathered no rust, was spared the weatherbeating of life. Hartman, and his other zoological associates, appreciate his extraordinary preparation for the culminating discovery of his life. He was not a product of lucky coincidences. His training conformed to the classic scientific pattern. Up to the final illness, his career shows that extraordinary kinetic drive which is a priceless gift in science. Though he died too soon to display to the full the orderliness and grasp of his mind, his indefatigable industry was reinforced by the ability to distinguish almost on the instant between the essential and the non-essential in a problem. He therefore moved with directness upon his objective, wasting neither time nor force on minor issues. The result was a succession of genuine bursts of discovery—a few hours, a few days sufficed to change the whole face of modern medicine, as in the *pallida* work. As one who has had some experience of the difficulties that have confronted post-Schaudinn syphilology, to me the astonishing thing is not alone the prepared mind but the astounding eyesight. Recall that in 1905 no satisfactory darkfield equipment existed. E. Hoffmann had used the Zeiss dark chamber in a search for the organism of syphilis in 1904, without success, and nothing of the sort we know to-day was available until Landsteiner and Mucha demonstrated the organism with the Reichert substage condenser in 1906 (Novy). Schaudinn, a trained microscopist, with a vision superacute through the study of minute organisms in his work on the parasitology of birds, at once saw, in the fresh preparation, what literally dozens of the ablest investigators of the day must have had pass uncomprehended before their eyes. It is a curious commentary on the claims of the great to super-greatness that Bordet and Gengou had, according to Metchnikoff, undoubtedly seen the spirillum of syphilis in a single drop preparation in 1903. They saw nothing in the second preparation, and, as so often happens, the glory passed from them and was gone. It is impossible to escape a thrill of predestination, a sense of the almost intolerably dramatic, in the moment when Schaudinn's mind crossed swords with the problem within the field of the microscopic objective. Something in the universe clicked. What might have been, had he been permitted to go forward to the problems of the life cycle and biologic defense, of symbiosis and pathogenetic mechanism—had he been spared to work with Ehrlich on the chemotherapy—only leaves us with a more tragic sense of loss.

While we yield first place, then, to the undoubted genius, we may draw a little practical guidance from his career. How shall we break the front of an embattled, a seemingly impregnable problem? First, there must be a *man* to whom work is divine, to whom it is meat and drink, rest and play—perhaps even sometimes, as in Schaudinn's fellow Spirochaetenforscher, Noguchi, almost home and love. Such men are few. There must be a fitness of the mind and body to the task. After the man there must come method. He must develop an instrument, a technique

with which he attacks his problems. This method will perhaps always contain some elements of the intuitive, the esoteric. But as rapidly as possible these should be reduced to the objective factual basis which alone makes possible scientific control. Into biologic research, dealing with mutable and changing material, plastic to influences often unconsciously exerted, there creeps an unusual element of personal equation, too often overlooked. It was said of Noguchi that for a long time an unconscious trick, probably due to his one-handedness, of carrying cultures between incubator and microscope in his vest pocket, of which he was never aware, prevented the confirmation by others of his results in cultivating the *Spirochaeta pallida*. I have seen abundant evidence that Warthin has left behind him many unsolved problems in the personal equation of spirochetal staining methods, which even his coworker Starry may have trouble in solving. Schaudinn was no desk-man, as his biographers say. His published notes and papers reach, however, a total of fifty. When he died a rich field lay buried in uncompleted publications and observations referred to only by a word here and there. Perhaps it is always so. But it illustrates what to me in these complex and crowded days is a desirable, perhaps an essential quality in an investigator. He keeps his table, and thereby his mind, mopped up. It is all very well to minimize publication, and to rate it for what it too often is, a cheap substitute for work. But the devices of honest publication are sufficiently varied now to permit, and in fact require, that the trained man *communicate* as he goes along, rather than to leave a mass of unintelligible and useless notes, or the second-hand impressions of a single assistant to carry on.

And lastly, the third essential to the investigator nowadays is persistent singleness of purpose. Occasionally genius may still perhaps scatter over the whole field of a science a series of germinal or epochal discoveries. Most of us would fare much better, however, and serve more effectively if, like Emil Fischer, we selected our field and perfected one or two tools with which in a lifetime to lay it clean and open, like the well-plowed furrow, to all mankind. Thus indeed, it needed in 1905 a zoologist, a parasitologist and a Spirochaetenforscher, rather than a bacteriologist and a medical man, to uncover what many had seen, unknowing.

In a reflective moment after this review of Schaudinn's life, a syphilologist may pause to look back over the directional influence of such a discovery and its fruits. A ready comparison or contrast is at hand in the discovery by Neisser of the gonococcus. The two discoveries opened similar roads. It is impossible to escape the belief that the concentration of intellectual forces upon syphilis, as contrasted with gonorrhea, arose to some extent from the intriguing Mephistophelian quality of the one, the sordidly venereal quality of the other. Neisser himself lived to advanced years, was throughout his life one of the foremost clinicians of Europe and an organizer of facilities that might well have embraced at least the machinery for the chemotherapeutic conquest of gonorrhea. Yet nothing has come of it. The discovery of the organism has at least achieved full use in diagnosis. Schaudinn was cut off, but by the identification of the organism among the Spirochaetes, he passed the torch, so to speak, to Ehrlich, who had been a student of the chemotherapy of trypanosomiases, near relatives of the spirochaetoses. Then flowered forth the whole modern structure of treatment, only for it to be discovered, after a decade or so, that it was, in a sense, a premature blooming. The original discovery of Schaudinn has never yet been carried to its logical outcome for practical medicine—the development of easily available, universally applied methods for the recognition of the organism by the everyday doctor or his laboratory deputy. Yet how essential such a simplified detection must be to the present-day problem of syphilis is daily reemphasized. And curiously enough, yet another epochal development in the syphilologic field has crossed the path of Schaudinn's discovery, to its deferred and even partially defeated usefulness. The Wassermann test, developed with the acclaim and support of the medical profession, overshadowed from the start the early recognition of the organism. To-day, to thousands of physicians, syphilis is summed up and described in terms of a positive Wassermann test on the blood. How few know it in that far more significant phase for the public health and the ultimate extinction of the infection—the seronegative, dark-field-positive syphilis of the first few days of the primary sore? Yet this is the truly significant syphilis of the future, the one moment that brings the modern chemotherapy to its full possibilities. The serologic tests, negative at this most significant moment, by their emphasis on diagnosis in the later stages, important rather for the individual at the moment than for the race in the ultimate, have delayed the perfection of Schaudinn's discovery to its fullest usefulness.

Nothing more clearly presents to my mind the enormous difficulties that beset biologic research and the devastating nature of a loss such as that of Schaudinn than the present status of the *Spirochaeta pallida* as a scientific asset. The efforts to develop a virulent organism in culture, the first step to biochemical advance by other than hit-or-miss methods in chemotherapeutic control, has apparently made

little headway, in spite of the genius of Noguchi. Twenty-five years after Schaudinn's announcement—a period longer than that which has sufficed to change the whole face of modern physics, for example—and his predictions as to the life cycle, so much needed both for clinical comprehension and treatment research lie almost where they were when he left them. In the recent announcements of Warthin, and of Levaditi, there is little more than Schaudinn foreshadowed in his first communications.

But is there nothing left us but a sense of loss? Before it is too late, perhaps a biographer may provide us with the material for a genuine personality study of the discoverer of the *Spirochaeta pallida*. Then we may know, perhaps, his inward motivations, his possible sense of destiny, if such existed, his foibles, his forebears, his inspired moments, the molders of his personality. I regret that I have not been able to lay such a study before you. But I can console myself, and perhaps, to some degree, you, too, by asking you to consider in the light of what I have told you, what are the critical essentials of a life. Was his death at thirty-five all tragedy? He escaped all need for debunking, not having lived into the middle period when accumulated responsibility and flagging energies might have demanded first a front and then a mask to conceal a slowly creeping inadequacy. There is something Grecian, Jovian, majestic, in the end. Just as there is much in his work and his discoveries that seems to spring, as Athene, full-blown from the forehead of Zeus, so he vanishes, as she did, in a thunder-clap from the summit of Olympus. But what are the critical essentials of a life, to be measured by deeds rather than by length of days? Surely they lie not in the time or manner of the ending but in the *living*. As I name them, you will know that Schaudinn lived them. They are, to use the utmost talent, to the utmost, for good.

SCIENTIFIC EVENTS

THE UNIVERSITY OF WISCONSIN RESEARCH PATENTS

PATENTS on eleven processes discovered by twelve members of the faculty of the University of Wisconsin are controlled in the public interest and at the same time protected from possible unrestrained exploitation by the Wisconsin Alumni Foundation at the university. The peoples of twelve nations in various parts of the world are protected by these patents, which are held at the University of Wisconsin. The nations in which they have either been taken out or applied for include the United States, Canada, Great Britain, France, Belgium, Germany, Argentina, Italy, Norway, Sweden, Denmark and Brazil.

The foundation is the only one of its kind in existence at any university or college, is an organization through which the results of research at the university are used for the public benefit through corporate channels. Established in 1925, its purposes according to its charter are:

> To promote, encourage and aid scientific investigations and research at the university and to assist in providing the means and machinery by which the scientific discoveries and inventions of the staff may be developed and patented and the public and commercial uses thereof determined; and by which such utilization may be made of such discoveries and inventions and patent rights as may tend to stimulate and promote and provide funds for further scientific investigation and research within said university.

The most recent scientific discovery, for which a patent has been applied for, is the new welding process invented recently by Professor Edward Bennett.

Other processes on which the foundation has patent rights and the names of those responsible for their discovery are: Antirachitic activation of medicinal and food products by ultra-violet irradiation, by Professor Harry Steenbock; improvements in process of producing lactic and acetic acids, by Professors E. B. Fred and W. H. Peterson; liquid air freezing of hard-shell seeds, by Mr. W. Busse; use of copper and iron salts in anemia, by Professor E. B. Hart; acetic acid and glucose fermentations of cellulose, by Mr. P. A. Tetrault; apparatus for measuring venous pressure, by Professor J. A. E. Eyster; leavening agent, by Mr. E. O. Wiig; mechanic's cleanser, by Professor Farrington Daniels; pituitary hormones, by Professor F. L. Hisaw, and marine paint, by Dr. L. C. Hurd.

THE BIOLOGICAL PHOTOGRAPHIC ASSOCIATION

THE great value of microscopic motion pictures to research workers in medicine and biology has been expressed by Dr. Heinz Rosenberger, of the Rockefeller Institute for Medical Research, and others, meeting at Yale University to organize the Biological Photographic Association, the first of its kind. The *New York Herald-Tribune* reports that the organization was started with thirty-five members, from the United States and Canada, with Dr. Ralph P. Creer, director of photography in the School of Medicine of Yale University, as its first president.

Speaking on "Micro-cinematography in the Research Laboratory," Dr. Rosenberger declared that to-day "all institutions of learning know the value of the motion picture, particularly the microscopic

motion picture, as a means of demonstration. By their domination of time, motion pictures are of enormous help to research workers, since the human eye has its limitations." He described an apparatus set up by the Rockefeller Institute for the study of heart disease, and exhibited one taking motion pictures of human capillaries.

Mr. Herbert Ingram, of Rochester, N. Y., declared that photographic evidence should form the basis for intelligent research and case records. He said further:

Hospitals should record reliable, accurate case details with supplementary pictorial history. There must be a clinical photograph of the patient, a photograph of diseased tissue, perhaps removed, a photomicrograph of the tissue structure and, in case of cardiac disease, an electro cardiogram.

Photographs of rare skin diseases, intra-abdominal tumors, external glandular malformations, postures and a host of other pathologies provide invaluable data. The diagnosis of disease becomes much simpler by having a visual as well as written record of the progress of a disease.

Many physicians engaged in orthopedic work forget the details of patients who later become involved in medico-legal proceedings. The doctor is at a loss to explain many details of treatment and the progress of injuries without photographic evidence. Motion picture studies of surgical and medical techniques form a newer field than photography and have great possibilities as a teaching medium.

A scientific example of the value of motion pictures would be a photographic study of various gaits, such as ataxia, propulsion and Parkinson's disease. Another possible field is in animal research—to record the results of experiments in diet and in the study of the effects of vaccines.

Dr. Carl D. Clark, director of art and photography at the University of Maryland, was chosen vice-president of the association, and Theodore Nelcey, of the School of Medicine, of Yale University, secretary-treasurer. The directors named are: Dr. Louis Schmidt, of the Rockefeller Institute; Dr. A. B. Soule, of the University of Vermont, and Miss Stella Zimmer, of Syracuse University. The conference ended with an inspection of the Yale University buildings.

THE TULSA MEETING OF THE GEOLOGICAL SOCIETY OF AMERICA

THE forty-fourth annual meeting of the Geological Society of America will be held on Tuesday, Wednesday and Thursday, December 29 to 31, at Tulsa, Oklahoma, under the auspices of the Tulsa Geological Society, and on invitation of the American Association of Petroleum Geologists. Headquarters, place of registration and exhibits will be in the Mayo Hotel. The headquarters of the council will also be at the Mayo Hotel, where the scientific sessions will be held. The address of the retiring president, Dr. Alfred C. Lane on "Eutopotropism" will be delivered in the auditorium of the Central High School, on December 29, at 8 o'clock.

Fellows are urged to submit without delay the titles and abstracts of papers which they wish to present at the meeting, so that the program committee may arrange to advantage a program of the sessions. By order of the council, no paper will be considered for the program unless the title is accompanied by an abstract suitable for printing in the proceedings of the society.

All sessions are open to the general public, but the council requests each fellow to send to the secretary as soon as practicable, and not later than December 15, the names and addresses of advanced students or other persons who are seriously interested in geology and are deserving of recognition as visitors. The council will then invite them to attend the meeting.

The affiliated societies which are meeting with the Geological Society of America are:

The Paleontological Society; secretary, B. F. Howell, Princeton University, Princeton, N. J.

The Mineralogical Society of America; secretary, F. R. Van Horn, Case School of Applied Science, Cleveland, Ohio.

The Society of Economic Geologists; secretary, Edward Sampson, Princeton University, Princeton, N. J.

Section E of the American Association for the Advancement of Science will hold meetings in New Orleans, Louisiana, on January 1, 1932, and a joint session with the Geological Society of America is being arranged. On Saturday, January 2, a field trip is planned to the salt domes and salt mines of Teche County.

THE SEVENTH PAN-AMERICAN SCIENTIFIC CONGRESS

THE Seventh Pan-American Scientific Congress will be held in Mexico City from February 5 to 19, 1932.

The program of the congress will be concerned with the physical and mathematical sciences; general and applied geology; engineering; industrial chemistry; biology; scientific agriculture; medicine; hygiene and public health; anthropological and historical sciences; juridical sciences; social and economic sciences, and education.

Members of the congress will include the official representatives of the countries that decide to take part; the representatives of universities, institutions and scientific associations in American countries; the

nationals of the countries taking part in the congress and the foreigners residing in them who receive a special invitation from the organizing committee; the authors of papers presented to the congress; all other persons who wish to inscribe themselves and who possess a university degree or who by other ways prove, to the satisfaction of the secretariat general of the Congress, their interest in scientific matters.

The organizing committee extends a cordial invitation to all scientists of America to attend the congress and to take part in its labors. "The sessions will promote the knowledge of the progress made in the various countries of the continent, in order to study and discuss some of the outstanding problems of those nations and will help to set up closer bonds of lasting friendship between the various countries. Mexico awaits enthusiastically the visit of those who will be its guests for a few days, during which both the authorities and the organizing committee will spare no effort to make their stay in the country as agreeable as possible in every way."

Dr. Alfonso Pruneda, President of the Organizing Committee, c/o Comision Organizadora del Septimo Congreso Cientifico Americano, Apartado Postal 517, Mexico, D.F., will send descriptive pamphlets on request.

THE AMERICAN INSTITUTE OF PHYSICS

To meet a generally recognized need for an agency suitably constituted to undertake cooperative projects, the American Physical Society, the Optical Society of America, the Acoustical Society of America and the Society of Rheology have formed the American Institute of Physics. This new organization is controlled by the four societies, and certain specific tasks have been outlined for its first efforts. It does not have individual memberships at the present time, and its constitution is still in process of development. The headquarters office of the institute is at 654 Madison Avenue, New York, N. Y.

Three major tasks have been set for the immediate attention of the institute. The first and most pressing is concerned with the journals of the four societies, which include *The Physical Review, Reviews of Modern Physics, Physics,* the *Journal of the Optical Society,* the *Review of Scientific Instruments,* the *Journal of the Acoustical Society,* and the *Journal of Rheology.* With perhaps one exception these journals are projects which the societies find increasingly difficult to support. And yet they are vitally necessary publications. This situation was brought to the attention of the Chemical Foundation, whose financial assistance in publications of a scientific character is well known. In conference it was recommended that a cooperative organization representative, so far as possible, of all physics should be formed at once, and the material help of the Chemical Foundation in such a project was promised.

While detailed plans have not been completed for meeting the problem of publication, it is expected that a combination of certain functions will be recommended. The business of subscriptions, advertising, printing and mailing, for example, could be carried on in one office for all the journals, probably with increased economy. There is, however, no thought of taking over the editorial function. That should remain with the individual societies.

The second function of the institute is to make contact with the newspapers and news magazines of the country with a twofold object. On the one hand, it is desired to help journalists prepare their articles to meet higher standards of accuracy and suitability. On the other, the institute aims to increase the public interest in physics, taking cognizance of the fact that the financial support accorded any human activity is in proportion to the intensity and breadth of interest which it inspires.

The four societies which have established the institute realize that there are numerous other groups, national and local in scope, of physicists or those who are interested in physics. They wish through the institute to invite the cooperation of these groups in mutual service and in national projects. A study of the proper steps to take in this direction is being made as a third function of the institute.

A cooperative committee of the four societies has now become the governing board of the American Institute of Physics. It consists of three representatives chosen by each society, making a board of twelve in all. The initial personnel is as follows:

Physical Society: Karl T. Compton, chairman of the board; George B. Pegram, secretary; John T. Tate.

Optical Society: Paul D. Foote, Loyd A. Jones, F. K. Richtmyer.

Acoustical Society: H. D. Arnold, Harvey Fletcher, F. A. Saunders.

Society of Rheology: E. C. Bingham, Wheeler P. Davey, A. Stuart Hunter.

It is contemplated that normally each member shall serve three years, a new representative to be elected to replace one retiring each year by each society.

At a meeting held at Schenectady in September, the board appointed Dr. Henry A. Barton, assistant professor of physics at Cornell University, to act as director of the new institute. Dr. John T. Tate, professor of physics, University of Minnesota, who is editor of the journals of the Physical Society, was appointed adviser on publications.

The first public activity of the new institute consisted of a dinner to journalists held at the New York Athletic Club on November 10. This dinner was very well attended by newspapermen and magazine editors

and so laid a basis for the work of the institute as regards public relations. Mr. Howard W. Blakeslee, science editor of the Associated Press, served as toastmaster. Dr. Karl T. Compton, president of Massachusetts Institute of Technology, addressed the guests on the subject of the American Institute of Physics. His brother, Dr. Arthur H. Compton, of the University of Chicago, then spoke on "Recent Developments in Physics in Europe," in particular those concerned with the atomic nucleus.

Mr. Waldemar Kaempffert, science editor of *The New York Times*, and Mr. Watson Davis, managing editor of Science Service, spoke for the journalists. They welcomed the formation of the institute in very gratifying terms, emphasizing the news value of scientific developments and promising the whole-hearted cooperation of the press.

The program concluded with a demonstration by Dr. Robert J. Van de Graaff of his recently announced electrostatic high voltage generator.

SCIENTIFIC NOTES AND NEWS

THE Nobel Prize in chemistry for 1931 has been awarded jointly to Dr. Frederick Bergius, general director of the I.-G. Farbenindustrie, Ludwigshafen, and to Professor Karl Bosch, of the University of Heidelberg.

DR. JOHN J. ABEL, professor of pharmacology and experimental therapeutics in the Johns Hopkins University School of Medicine, has announced his intention of retiring from the chair at the end of the present academic year. Dr. Abel's retirement is the outcome of a desire, on his part, to be relieved of academic duties in order that he may devote his entire time to his own investigations and to editorial work in connection with *The Journal of Pharmacology and Experimental Therapeutics*.

DR. W. H. WRIGHT, astronomer at the Lick Observatory of the University of California, has been appointed faculty research lecturer for the year 1931–1932. This is the highest honor which the faculty can award to one of its members during the academic year. The lecture will be delivered on the eve of the sixty-fourth anniversary of the founding of the university on March 23, 1932.

A DINNER in honor of Professor Winterton C. Curtis, who has completed thirty years of service in the zoology department at the University of Missouri, was given on November 7. The speakers were Dr. F. H. Woods, Dr. Lewis Stadler and President Walter Williams, of the University of Missouri; Colonel Lloyd E. Thatcher, of the Branham-Hughes Military Academy, and Father Alphonse M. Schwitalla, of St. Louis University. It was announced that a fund of $2,100 had been raised to establish a graduate scholarship in zoology for summer study at marine laboratories.

MR. L. A. SPINDLER, of the zoological division of the U. S. Bureau of Animal Industry, was on November 6 the guest of the departments of medical zoology of the School of Hygiene and Public Health at the Johns Hopkins University. As after luncheon speaker Dr. Spindler told of his experiences in the southern United States and later in the day gave a lecture on the life history of the nodule worm *Oesophagostomum longicaudum*.

ON the occasion of the opening of the new laboratory of physical chemistry at the University of Freiburg im Breisgau on October 30, honorary degrees were conferred on Lord Rutherford, Professor Manne Siegbahn, professor of general physics in the University of Uppsala, and Professor V. M. Goldschmidt, of Göttingen.

AN oil painting of the late Dr. S. Z. de Ferranti, an honorary member and past president of the British Institution of Electrical Engineers, has been presented to the institution by Mr. H. Marryat.

PROFESSOR ROBERT DECOURCY WARD, professor of climatology at Harvard University, died on November 12 in his sixty-fourth year.

DR. JAMES SIMPSON CHESTER WELLS, adjunct professor of analytical chemistry at Columbia University from 1905 to 1909, died on October 29 at the age of eighty years.

DR. JOSEPH KITTREDGE, JR., senior silviculturist at the Lake Forest Experiment Station of the University of Minnesota, has been appointed professor of forestry at the University of California and forester at the experiment station.

MR. WILLIAM J. MILLER, formerly dean of the school of engineering and head of the department of electrical engineering in the Texas Technological College, has been elected head of the electrical engineering department at the University of North Carolina. He succeeds Dr. Parker H. Daggett.

AT the University of Pennsylvania School of Medicine, Dr. Albert E. Roussel, professor of medicine, and Dr. James E. Talley, professor of cardiology, have been made professors emeritus.

DR. LESLIE T. GAGER, clinical associate in medicine at the George Washington University Medical School,

has been appointed professor and head of the department of medicine at the Howard University School of Medicine.

DR. E. T. BODENBERG has been appointed assistant professor of biology at Wittenberg College.

DR. HOWARD JAMES STOVER, instructor in price and statistics in the department of agricultural economics at the New York State College of Agriculture at Cornell University, has been appointed assistant agricultural economist to the Giannini Foundation of the University of California.

DR. J. HOLMES MARTIN, of the University of Kentucky, has been appointed managing editor of *Poultry Science*, to succeed Dr. L. E. Card, who, after serving for eight years, relinquished his office with the November issue of the journal.

THE council of the Institution of Chemical Engineers of Great Britain has appointed Mr. H. W. Cremer to be honorary secretary in succession to the late Professor J. W. Hinchley.

PROFESSOR KANZAEMON KUKUCHI, head of the department of biology of the Toyama High School, Japan, is studying the collections of oriental invertebrates at the U. S. National Museum. Dr. Teiichi Kobayashi, of the Geological Institute of the Imperial University, Tokyo, Japan, has also arrived at the museum with a large collection of early Paleozoic fossils.

THE *Museums Journal* reports that Mr. Frank H. H. Roberts, of the Bureau of American Ethnology, spent the summer conducting a series of excavations in a pit house site south of Allantown, Arizona. Fifteen pit houses were uncovered and specimens of pottery, stone and bone implements, arrow heads, spear points and pendants were obtained.

AT the annual meeting of Delta Omega, the honorary public health society, which was held in the Windsor Hotel on September 14, Dr. James A. Tobey, of New York, was elected national president, succeeding Dr. John A. Ferrell. Professor Charles G. Hyde, of the University of California, was elected vice-president, and Professor Ira V. Hiscock, of the Yale School of Medicine, was reelected as secretary-treasurer. Dr. Mazyck P. Ravenel, of the University of Missouri, was elected as the ninth national honorary member of the society.

IT is reported in *Nature* that officers of the Philosophical Society of the University of Durham have been elected as follows: *President,* Professor R. A. Sampson; *vice-presidents,* Sir Westcott Abell, Professor G. R. Goldsbrough, Professor T. H. Havelock, Professor P. J. Heawood, Sir William Marris, Professor J. Irvine Masson; *honorary general secretary,* Mr. W. M. Madgin; *honorary treasurer,* Mr. J. W. Bullerwell; *editor,* Professor G. W. Todd, and *honorary librarian,* Dr. F. Bradshaw.

THE New York County Medical Society has held its monthly meeting at which officers for the coming year were nominated as follows: *President,* Dr. David J. Kaliski, Beth Israel Hospital; *first vice-president,* Dr. Terry M. Townsend, West Side Dispensary; *second vice-president,* Dr. Walter T. Danpreuther, Postgraduate Hospital; *secretary and director,* Dr. Daniel S. Dougherty, Polyclinic Hospital; *assistant secretary,* Dr. Peter Irving, Roosevelt Hospital; *treasurer,* Dr. George Kosmak, Women's Hospital; *assistant treasurer,* Dr. Ten Eyck Elmendorf. Dr. Charles Gordon Heyd, president, presided. The election will be held next month. Two new amendments to the organization's constitution were read. They call for the creation of the office of president-elect and a board of five trustees. The amendments also will be voted upon at the meeting on November 23.

DR. ROBERT A. MILLIKAN delivered a lecture on recent progress in experimental physics at the Kaiser Wilhelm Institute, Berlin, on November 13.

DR. EDGAR DOUGLAS ADRIAN, Foulerton research professor of the Royal Society at the University of Cambridge, delivered a lecture at Harvard University Medical School on November 3 on "Sense Organs and Nerve Cells."

AT the meeting of the American Mathematical Society in New York on October 31, Professor D. V. Widder, of Harvard University, at the request of the program committee, delivered an address entitled "Some Recent Developments in the Theory of Laplace Integrals."

THE seventeenth annual meeting of the American Association of Petroleum Geologists will be held at Oklahoma City on March 24, 25 and 26, 1932, at the Biltmore Hotel. The Oklahoma City Geological Society is arranging entertainment for the meeting. The Society of Economic Paleontologists and Mineralogists, a technical division of the association, will hold a concurrent meeting. Special entertainment and a technical program are being arranged.

AN International Mathematical Congress will be held in Zurich, Switzerland, from September 4 to 12, 1932, all nations participating. The president of the committee on organization is Professor R. Fueter, of the University of Zurich.

THE Chemical Foundation has given $10,950 to Columbia University, of which $10,000 is for research in biological chemistry and $950 for research in bacteriology.

DR. E. D. MERRILL, director of the New York

Botanical Garden, has made an agreement with Lingnan University, Canton, China, for cooperative work in the botanical exploration of southern China.

THE South Carolina Food Research Laboratory at the State Medical College, Charleston, is in receipt of a grant of $13,000 from Mr. Bernard M. Baruch, to forward its investigations into the relation of diet to the etiology of simple goiter. A considerable portion of the grant will be used in studying seasonal and other variations in the amount of iodine available normally in the environment of people in goitrous and non-goitrous regions. Goiter is not endemic in South Carolina.

THE American Mathematical Society has recently concluded two reciprocity agreements with foreign organizations similar to the one now in force between the society and the London Mathematical Society. The new agreements are with the Unione Matematica Italiana and the Deutsche Mathematiker-Vereinigung. Besides other privileges, members of one of these foreign organizations may become members of the American Mathematical Society on the payment of initiation fee and one half the annual dues, and members of the American Mathematical Society may become members of the foreign organizations on the same terms.

TWO journals of eugenics have been established recently. One, *Genesis,* is published quarterly by the Italian Federation of Eugenics; the other, *Eugenics,* is the monthly organ of the Japanese Eugenics Institute.

THE Black Rock Forest Laboratory at Cornwall-on-the-Hudson, New York, has been elected to membership in the International Union of Forest Research Organizations.

THE report of the council of the senate of the University of Cambridge on the establishment of a Goldsmiths professorship of metallurgy recommends that the Goldsmiths readership in metallurgy be discontinued and that on the establishment of the professorship the stipend of the professor be £1,200 a year.

A RECOMMENDATION is made by the general board of the University of Cambridge that in the interests of economy and simplification of administration the department of aeronautics should be suppressed and amalgamated with the department of engineering.

AT a meeting of the Royal College of Physicians of Edinburgh, held on October 14, it was resolved that in view of the national situation, the ceremonies in connection with the celebration of the two hundred and fiftieth anniversary of the foundation of the college be postponed to a future date.

THE 69-inch mirror for the Perkins Observatory telescope at Delaware, Ohio, is now undergoing final tests at the factory of Mr. J. W. Fecker, in Pittsburgh, according to an announcement by Dr. Harlan T. Stetson, director of the observatory. Invited scientists cooperating in these tests are: Dr. J. S. Plaskett, director of the Dominion Astrophysical Observatory at Victoria, British Columbia, and Dr. I. C. Gardner, of the optical division of the Bureau of Standards. An addition to the Mining Laboratories of the University of Toronto, built at a cost of $250,000, was opened on November 7. The principal address was given by the Honorable Charles McCrea, minister of mines for the province of Ontario, which made the appropriation for the building. In the evening a number of prominent mining men and former students of Professor H. E. T. Haultain, professor of mining engineering in the University of Toronto since 1908, tendered him a complimentary dinner in honor of the occasion.

DR. EDWARD R. WEIDLEIN, director of the Mellon Institute of Industrial Research, Pittsburgh, has announced that the institution has accepted from the National Grain Yeast Corporation, Belleville, N. J., a grant for a comprehensive investigation of the chemistry and technology of yeast. This research, which will be operated as an industrial fellowship of the institute, will be conducted with the close collaboration of specialists in the donor's organization. The results will be made available as the various stages of the studies are completed. Dr. Roy Irvin, a food and nutritional chemist, has been appointed to the incumbency of the fellowship. He has been a fellow of Mellon Institute since 1917, following the completion of his professional graduate work at the University of Kansas, and has contributed to the literature of bread and baking technology, cereal products and eating habits.

ENGINEERING graduates of Cornell University celebrated the sixtieth anniversary of the founding of the College of Engineering on October 17. Tribute was paid to the memory of Hiram Sibley, of Rochester, first president and founder of the Western Union Telegraph Company, through whose gifts the beginnings of the engineering college were made possible. As a part of the celebration the engineering alumni joined in the world-wide observance of the one hundredth anniversary of Faraday's discovery of the principle of electromagnetism. George S. Moler, professor emeritus, reenacted the historic scene when Professor W. A. Anthony and he in 1875 generated electricity with a dynamo they constructed according to Faraday's plans and lighted the Cornell campus while New York and Paris were still using gas illumination.

THE assistance which the Citrus Laboratories of

the U. S. Department of Agriculture have rendered citrus-fruit growers of California and Florida in solving problems of by-product disposal has led to the extension of this work to Texas, following repeated requests for such aid from fruit growers of that state. The last congress appropriated funds for the laboratory which is to be placed on the state-owned land of the Texas State Agricultural Station at Weslaco. Total plantings of citrus in Texas amount to approximately 6,650,000 trees, about half of which are now bearing. This represents an acreage of about 90,000, with grapefruit accounting for three fourths of the total.

THE department of zoology at New Jersey College for Women (the undergraduate woman's college of Rutgers University), New Brunswick, has opened, in its zoology building, a new teaching museum, occupying the room known as the Yardley Memorial Room, in memory of Mrs. Margaret Tufts Yardley, first president of the New Jersey State Federation of Women's Clubs, under whose direction the money for the building was raised, and given by the federation to the college for a hall of science. The museum, equipped with aluminum-frame cases and glass shelves, houses about half the teaching exhibits of the department of zoology. These exhibits are on display to the public, and consist of a series of some 225 mounted birds, representing the species found in New Jersey, together with about 90 skins of birds, both native and exotic; an exhibit of the hawks of the state, so placarded as to bring out their value or detriment to agriculture; a series of skeletons of typical vertebrates and of skeletal parts disarticulated; a series of preserved materials, such as human embryos, embryological series of rat and bird, typical reptilia, vertebrate brain series, human brain, head of an Egyptian mummy (probably predynastic), and miscellaneous material; some 50 anatomical models, both human and infra-human mammal structures, and preserved specimens forming a systematic collection of all phyla of animals, as well as a series of the common invertebrata and smaller vertebrata of the state. This last item numbers some 200 exhibits, and is largely divided up among the different laboratories in the building.

NATIONAL forest area in Eastern, Southern and Lake States will be increased by the purchase of 16,558 acres of forest land recently approved by the National Forest Reservation Commission, which authorized the expenditure of $52,624.82 for the purpose. The commission took recess action in order to advance the date of payment by some six months, as most of the purchases are to be made in areas affected by last year's drought or handicapped by unfavorable financial conditions and unemployment. Individual purchases approved will number 166, involving mainly small tracts. Prompt payment of cash for these holdings is expected to afford some relief to individual owners and local communities. Lands acquired will be added to existing national forest purchase units already protected and administered by the Forest Service for continuous development of forest resources and safeguarding of watershed values. More than half the proposed new purchases lie in or are contiguous to the Ozark and Ouachita National Forests in Arkansas, and 1,121 acres are in the Kiamichi forest purchase unit in Oklahoma. The Nantahala National Forest in the southern Appalachians will be increased by 1,612 acres. About 2,500 acres are to be added to other forests in the South, 389 to the White Mountain National Forest, and 1,858 to purchase units in the Lake States.

ACCORDING to the *Journal of Education* the Cuban National University, which has been closed since September, 1930, was reopened this fall under an entirely new plan which will remove it from the direct supervision of the government, according to the proposal of Dr. Carlos Miguel de Cespedes, secretary of public instruction, who is working out the details of a proposal to be submitted to Congress. The plan is to turn over all buildings and grounds now owned by the state to the university, which will become a separate organization governed by a board of directors composed of twenty-six deans and professors who were appointed to the faculty in 1900 after competitive examinations. The government will arrange an endowment of $2,000,000. The matriculation fee will be set at $200 and the government will each year purchase 1,500 scholarships to be distributed among men and women who would be otherwise financially unable to attend the university.

DISCUSSION

OESTRUS

A LETTER in SCIENCE of March 27 by Professor S. A. Asdell, of Cornell, protests the misuse of *oestrum* for *oestrus,* affirming not only that the former, since it can not be a neuter nominative, must necessarily be a masculine accusative and so entirely unjustifiable; and also affirms that Heape introduced *oestrus* into literature as a synonym for animal tumescence. Is he quite correct in either statement? If not too late, may I be permitted briefly to trace the respective histories of the terms?

Oestrus is of course the Latin transliteration of the

Greek masculine noun οἶστρος, oistros (for which the purest Latinists are perhaps wont to employ either *asilus* or *tabanus*), and is therefore itself obviously of the same gender.

The Greek word originally referred to a dipterous insect infesting cattle (probably *tabanus bovinus*) the gad- or bot-fly, and in this sense is as old as Homer. Later, Aristotle employed it of a parasite of tunny-fish, and also of a small insectivorous bird. Meanwhile, by another line of evolution, it came figuratively to signify a sting, hence something that drives one mad; frenzy, insane impulse, mad passion, etc., and is so employed by the writers of the golden period of Greece.

So far as I know, its Latin transliteration is first found in Virgil. But it is still masculine, as in Pliny.

We must now take a leap across the centuries to the learned Isidore of Seville (*c.* 600 A.D.), who, in his "Origines," is apparently the earliest writer to turn this masculine noun into a neuter. Why he did so must remain, in the absence of any evidence, inexplicable. In any case, his great reputation as a scholar apparently set a precedent for later writers. Du Cange, in his monumental "Glossarium Med. et Inf. Lat.," actually spells it oes, but refers to Isidore's *oestrum*.

Coming now to English literature, it is a fact that the neuter form has for some centuries been naturalized in our language. In 1656, for instance, S. Holland, applying the term to a flea, speaks of "defying the eagerness of those sanguine-coated *oestrums*." In 1706, Phillips defines the "*oestrum*, or *oestrus*," as "the gad-bee." Or Badham, in 1854, apparently recalling the zoology of Aristotle, refers to "the conduct of the poor thunny under the scourge of the sea *oestrum*." In 1663, Butler, in the famous "Hudibras," employs the neuter figuratively. "What *oestrum*, what phrenetick mood, makes you thus lavish of your blood?"

Coming still closer to the modern physiological connotation, Jefferson, in 1782 writes as follows: "Love is the peculiar *oestrum* of the poet"; which to the present writer, at least, suggests the lines from "Locksley Hall";

In the Spring a fuller crimson comes upon the robin's breast:
In the Spring the wanton lapwing gets himself another crest;

In the Spring a livelier iris changes on the burnish'd dove;
In the Spring a young man's fancy lightly turns to thoughts of love.

We come now to its definite physiological use. The earliest example that the Philological Society of England gives is dated 1772 (*Ann. Reg.*): "The times, in which animals of different species feel the *oestrum*, [note that it is neuter and not masculine] by which they are stimulated to the propagation of their respective kinds."

It would seem, therefore, (1) that *oestrum*, as used by modern physiologists, is not intended as a masculine accusative but a neuter nominative (with no philological justification, however, but only that of "the Tradition of the Elders"): and (2) that Heape, who wrote in the second half of the nineteenth century, etc., could not have introduced the word (in either its masculine or neuter dress) as applicable to animal tumescence, inasmuch as the last quotation antedates him by practically a century, and also, intrinsically, bears indications of being a record of a connotation already familiar in England.

Since writing the above, I find that Isidore was not the first writer to employ the neuter. At the close of a discussion of *oestrus*, Facciolatus and Forcellinus, in their "Totius Latinitatis Lexicon," have the following note. "Festus facit oestrum neut. gen., nam et Graece οἶστρον." The reference is undoubtedly to Sextus Pompeius Festus, the author of twenty books, "de Verborum Significatione." While his date is uncertain, he lived at a later period than Martial (*c.* A.D. 75) and before Macrobius (*c.* 400). Isidore perhaps made use of his lexicon, and thus standardized the error.

At how early a date there began the trend towards the modern physiological use of the term may be seen from the following citation from IV Macc., a Greek work by a Jewish Alexandrian scholar about A.D. 50. "For he, a young man at the age when physical desire is strong, by his reason quenched the mad impulse (οἶστρον—masc. acc.) of his passions. . . . The temperate mind is able to conquer the dictates of the passions, and to quench the fires of wild desire (οἰστρῶν)."

STUART L. TYSON

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POSSIBLE SIGNIFICANCE OF THE DECREASED SUSPENSION STABILITY OF THE BLOOD

THE decrease of the suspension stability of the blood, or the increased sedimentation rate of erythrocytes during disease, has provoked an enormous amount of investigation devoted chiefly to employing this phenomenon for diagnosis and prognosis of various illnesses. The fact that red cells settle more rapidly than normally in so great a number of diseases has led many to regard this phenomenon as too

general to be of value in diagnosis or prognosis. It is possible that the significance of the reaction has been largely overlooked in the efforts to apply it to practical purposes. It may, as Fahreus has already suggested, play a rôle as a factor in the defense mechanism of the body against infection. Fever easily lessens the suspension stability of the blood by causing an increase in the viscosity of the plasma. As a result there is a change in the electrical charge, the erythrocytes clump and settle rapidly. It has been demonstrated that both erythrocytes and bacteria carry negative charges. The assumption would then be that a decrease of the suspension stability of the blood would also favor clumping of bacteria circulating in the blood stream. If the hypothesis is correct that clumping of bacteria is the first step in the successful disposal of bacteria which gain entrance into the body it would appear that the ease with which the suspension stability is disturbed is of considerable significance. It would be logical to consider fever, which alters suspension stability, as one factor in protection against infection.

A number of experiments recently performed indicate that bacteria of various kinds (pneumococci, Friedländer's bacilli, typhoid bacilli) tend to aggregate and clump in plasma from blood exhibiting a marked decreased suspension stability but not in plasma obtained from a normal individual. The clumping is not striking but can often be observed microscopically. If a weak solution of gum acacia is added to increase the viscosity further, the reaction is markedly enhanced. For instance, acacia was added to one of two parallel series of tubes containing increasing dilutions of typhoid antiserum. Typhoid bacilli agglutinated in a far higher dilution of antiserum in the row of tubes containing the acacia. When typhoid bacilli are added to a 5 per cent. solution of acacia, motility is instantly retarded or stopped. Theobald Smith[1] has recently noted a similar phenomenon in the agglutinating action of agar on bacteria.

A few experiments *in vivo* were performed. Mice were inoculated intraperitoneally with a heavy suspension of type I pneumococci and divided into 3 groups. One group was injected intraperitoneally with 0.5 cc of a 10 per cent. solution of acacia, one group with .01 cc of type I antipneumococcus serum and the third group with acacia and antiserum. The mice were killed after ½ hour and 1 hour periods. Pneumococci and leucocytes showed much more clumping in the mice injected with acacia. Occasionally in the mice receiving acacia most of the pneumococci had disappeared, only a few clumps were seen attached to the large agglomerations of leucocytes. In the mice receiving the minute amount of immune serum, pneumococci were found in great numbers, often evenly distributed and not clumped. The observed differences in the three groups were most striking within one hour after inoculation.

It appears, from these experiments, that an increase in the viscosity both *in vitro* and *in vivo* enhances the agglutinative property of specific immune serum. Whether the increase of viscosity of blood plasma which accompanies fever likewise favors agglutination is as yet uncertain and is being investigated.

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[1] T. Smith, SCIENCE, 74, 21, 1931.

FOSSILS FROM THE EASTERN FLANK OF THE SIERRA NEVADA, CALIFORNIA

THE Sierra Nevada of California has been described as a huge fault block, tilted toward the southwest.[1] The northern end of this mountain mass departs considerably from so simple a form, and consists of several parallel ranges with intervening troughs,[2] but in the central and southern portions, the ideal condition of a simple, though dissected, fault block, seems to be much more nearly realized. The lofty escarpment, which limits the southern half of the Sierra Nevada on the eastern side, is composed mainly of plutonic intrusions, thought to have invaded an older series of igneous and sedimentary rocks in upper Jurassic time.[3] Occasional roof pendants of the older rocks occur along and west of the escarpment, at least as far south as Owens Lake, and farther north, in the vicinity of Mono Lake, they become quite large and abundant.

It would be desirable, both from a scientific and a practical standpoint to determine the age of the older rocks, and to correlate them with similar formations in adjoining regions. Unfortunately, however, fossils, although they have been reported from the western slope of the range, and from the northern portion, by various writers, are extremely rare along the eastern escarpment. Also, the geologic structures in the roof pendants are very complex, because of the intense folding and faulting that probably accompanied the intrusion of the plutonic rocks. The lithologic similarities are of doubtful value.

[1] Turner, H. W., "The Rocks of the Sierra Nevada." *U. S. Geol. Survey Fourteenth Annual Rept.*, pt. 2, pp. 435–496, 1894.

[2] Lindgren, Waldemar, and Knowlton, F. H., "The age of the auriferous gravels of the Sierra Nevada, with a report on the flora of Independence Hill," *Jour. Geology*, vol. 4, pp. 881–906, 1896.

[3] Turner, H. W., "The Pleistocene geology of the south central Sierra Nevada with especial reference to the origin of Yosemite Valley," *California Acad. Sci. Proc.*, 3d ser., Geology, vol. 1, pp. 261–321, 1900.

Recognizable organic remains have been found by Walcott[4] in a small, isolated area of lower Cambrian rocks at the base of the Sierra west of Big Pine, in Inyo County, and provisional Triassic forms from the roof pendant at Mineral King have been noted by Turner.[5] As yet, no report of fossils from any part of the escarpment between Big Pine and Mono Lake has been seen by the writer. For this reason, it may be of interest to record the recent finding of probable mid-Devonian fossils in crystalline limestone (marble) on the Sierra Nevada escarpment, about 28 miles south of Mono Lake, by Mr. W. E. Selbie, a prospector. The writer has spent three summers in geologic field work in this region, part of which was done under the auspices of the California State Division of Mines, and supervised by Dr. Olaf P. Jenkins, chief geologist. On various occasions during the investigation, Mr. Selbie rendered valuable assistance. He became interested in the progress of the work, and in the possibility of finding fossils in the older rocks.

A few months ago, Mr. Selbie sent to the Geology Department at Cornell University, a package containing two fossils, one a large crinoid stem (.4 inch in diameter), and the other a small brachiopod. These remains are stated by him to have been found in a bed of crystalline limestone, which outcrops on a mountain side a few hundred yards east of Laurel Creek, in southwestern Mono County. They were examined at Cornell University by Professor G. D. Harris, who states that the age of the fossils is uncertain, but they somewhat resemble mid-Devonian forms. The brachiopod is thought to be near *Leiorhynchus sp.* (?).

There can be little doubt that the Paleozoic rocks along the escarpment range in age from lower Cambrian to Devonian. Whether or not the whole of the Paleozoic section is represented remains uncertain. It is hoped that future investigation will yield further data to confirm those now at hand, and to enable further conclusions to be made. The finding of more fossils, over a wider area, would not only make it possible to recognize the formations present, but would offer a valuable check on interpretations of geologic structures in the older rocks.

EVANS B. MAYO

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NAMING DISORDERS OF SPEECH

REALIZING the need of a systematic international classification of disorders of speech and voice, the American Society for the Study of Disorders of Speech appointed a nomenclature committee three years ago to prepare such a classification. The committee felt that such a classification should not be published in entirety, however, until accurate definitions of every disorder of speech listed had been approved by at least the leaders in the field of speech correction.

In order to give all workers in this new field of science an opportunity to criticize the best definitions the committee were able to obtain, the committee has just published a tentative "Dictionary of Terms Dealing with Disorders of Speech," and requests those interested to revise every definition which does not adequately describe a given disorder of speech as they have actually known it, and to send the revision to the committee. Only so can an accurate revised edition of this dictionary accompany the publication of the final international classification of disorders of speech and of voice.

SAMUEL D. ROBBINS

SECRETARY AND CHAIRMAN OF NOMENCLATURE COMMITTEE

A CURIOUS FISH STORY

A QUITE curious case of gastric erosion of a fishhook that had been swallowed by a fish has come under my observation. Many experienced fishermen tell me that they have seen nothing quite like it. At about eight o'clock in the evening of July 1, Professor C. E. Hagie, of the History Department of Western State College, hooked a twelve-inch Loch Leven trout while fishing on the Gunnison River. When this fish was cleaned it was discovered that it had at some previous time swallowed a No. 2 Carlisle bait hook. The barb of this hook had penetrated the wall of the stomach and all of the curvature of the hook to a point on a level with the tip of the barb lay in the body cavity. The straight shank of the hook lay entirely in the stomach. Outside of the stomach the hook was in good condition; inside the stomach it had been so eroded by the gastric action that but a mere filament of the former metal was left.

An interesting question as to how long it may take for such erosion to be brought about presents itself. According to the best opinion that I can get at the hands of expert fishermen of long standing, a twelve-inch trout, in the Gunnison River, takes about three years to reach this size. Trout are put into the river as fingerlings. They grow rapidly and, in a year, according to food conditions, reach a length of about seven inches. In another year they reach a length of from eight to ten inches. The third year they may reach a length of twelve inches.

It would seem certain that the amount of erosion of the fishhook in the stomach of the fish in question would preclude the possibility of its having been swallowed during the present fishing season. This

[4] Walcott, C. D., "Lower Cambrian Rocks in Eastern California," *Amer. Jour Sci.*, 3d ser., vol. 49, pp. 141–144, 1895.

[5] Turner, H. W., *op. cit.*, p. 451.

erosion may have been the result of about a year of gastric action. It would also seem that such a hook would not have been broken from the leader by a trout only one year old, or one about seven inches in length, unless the fisherman had fastened it very carelessly. A two-year-old trout might possibly do this during the course of a lusty battle with the angler.

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WESTERN STATE COLLEGE OF COLORADO,
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AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

NEW ORLEANS MEETING, DECEMBER 28, 1931–JANUARY 2, 1932

EXCURSIONS AND TRANSPORTATION

THE outdoor weather of the mild New Orleans winter will enable delegates and visitors to take full advantage of the interesting trips sponsored by various sections and the general committee at the American Association for the Advancement of Science meeting, December 28 through January 2, according to Dr. Daniel S. Elliott, chairman of the local committee on preparations.

The historic French Quarter or Vieux Carré of New Orleans will receive special attention. Most sections, as well as the general committee, are planning to provide delegates with guides for convenient and informal sightseeing tours through this area. The Vieux Carré, the site of original white settlement in Louisiana, includes the dimensions of the first town built by the French under Bienville. Its museum collection, antique stores and picturesque atmosphere, and architecture cause it to be a Mecca for visitors from all over the world. Many buildings date back to the time of French and Spanish occupation. Its people, French and Italian, belong to Europe rather than America.

Avery Island in New Iberia Parish, the center of Louisiana's extensive salt-mining industry, is the goal set for a special outing sponsored by the geological section. Those participating in this excursion will leave New Orleans on the Southern Pacific Railway at 10:40 P. M., January 1, traveling in special Pullman cars which will be set out at New Iberia until 7:30 A. M., January 2. Immediately after breakfast the party will leave in busses for the interesting localities in that vicinity, under the leadership of members of the local committee for Section E. The salt domes and a wild life sanctuary which occupies a portion of the island will be visited on the morning of January 2. Sightseeing will include trips into the mine shafts, which extend several hundred feet underground, giving a view of a wide variety of salt formations.

The Association of Commerce of the town of New Iberia is extending its courtesies to visitors. After the trip through the mining districts there will be a dinner at a hotel in New Iberia. Returning, the party will leave New Iberia at 3:13 P. M., and arrive in New Orleans at 7:35 P. M., January 2. This will give an opportunity to see a salt dome and mine and jungle gardens, as well as many of the interesting features in the "Teche country," the land of Evangeline. The total cost for transportation, breakfast and luncheon will be approximately $10.80 for lower berth accommodations and $10.10 for upper berth accommodations. Reservation of space in this party should be made directly to Professor R. A. Steinmayer, Tulane University, New Orleans, La. As the party will be limited in number, it is strongly advised that all those who wish to join this party notify Professor Steinmayer at the earliest possible moment.

The engineering section will sponsor two excursions dealing with the general subject of flood control and its special application at New Orleans.

One afternoon will be given to a short visit to the Mississippi River spillway at Bonnet Carré, twenty-five miles northwest of the city. This project, constructed as a result of the flood season of 1927, is designed to divert excess high water from the Mississippi to Lake Pontchartrain, to protect New Orleans.

A tour of the city on another afternoon will take up in detail numerous features of interest to engineers. Among these will be the extensive pumping system which is necessary for city drainage, and the reclamation work now in progress along the shore of Lake Pontchartrain.

Specific dates and arrangements for these two trips are to be announced a little later through Professor W. B. Gregory, local representative for the engineering section.

Two field excursions are scheduled under the sponsorship of the local committee of the Ecological Society of America. One of these is to take place on Thursday, December 31, and the other on Friday, January 1.

For each trip the party will leave the St. Charles Hotel in special busses at 9 A. M., to return about 5 P. M. The outgoing trip will be via bridges over Pass Chef Menteur and Pass Rigolets. The return will be by way of one of the longest bridges in the world, which crosses Lake Pontchartrain for five miles.

Representative examples of marsh, bayou and cypress swamp in Orleans and St. Tammany Parishes will be visited.

The trip on Thursday will be attended largely by

members of the Ecological Society. Friday will be left open for the numbers of interested biologists and others who will probably be occupied with other sessions on the previous day. According to Dr. E. S. Hathaway, of the local committee, it is possible that a half-day excursion may be arranged for the benefit of those who can not take a whole day from other matters.

The local group of the Society of American Foresters will sponsor a somewhat detailed inspection of the forest industry at Bogalusa, La., on Thursday, December 31. The party will leave at 8 A. M. by automobile. At Bogalusa they will go through the experimental plant of the U. S. Forest Service and examine large planted areas maintained by the Great Southern Lumber Company.

On these latter lands will be shown examples of natural reproduction of longleaf pine, the effects of different methods of fire protection, the results of yearly burnings and numerous other aspects of practical forestry. Of especial interest will be the brown-spot spraying plots, demonstrating preventative measures taken against the brown-spot disease. The midday meal will be taken at the Louisiana State University's Forestry School Camp.

A tour of points of interest in the New Orleans harbor on the excursion steamer *Capitol* is being promoted by the mathematicians. Definite details in regard to this trip will be announced later, according to Dr. H. E. Buchanan, local representative of this section.

But the trips formally arranged by various sections represent only a few of the opportunities to be afforded visitors through arrangements for travel singly or in groups which are being worked out by the general committee.

By airplane or boat delegates will be able to visit Grand Isle, former rendezvous for the French pirates of the Gulf. The trip down the 110 miles of river which lie between New Orleans and the sea will be of interest because of the splendid woodland scenery and glimpses of the primitive life of the inhabitants. Waters in this area provide some of the best year-round fishing in the world, while the forests are teeming with wild life—ducks, geese, snipe, doves, rabbits, squirrels, bear, deer—most of which will be in season at the time of the meeting.

Sugar plantations during the interesting season of cane grinding will also be opened to visitors. Arrangements have been made with the Godchaux Plantation at Reserve, La., and Southdown Plantation at Houma.

The Evangeline country of the Teche will also attract the visitors. Short trips by bus and automobile to the towns of these French-speaking descendants of Longfellow's Acadians will be possible.

One of the numerous historical sites on the outskirts of New Orleans is the Chalmette battlefield, scene of the battle of New Orleans, in the War of 1812. It is still possible to walk over the very ground on which General Andrew Jackson's motley array of frontiersmen, French pirates, Negroes and Choctaw Indians turned back the tide of British invasion.

These journeys are planned to be informative—and to be more—to give delegates a better appreciation of atmosphere and conditions, facts and problems, in a land where French and American civilizations have impacted and fused.

The United Fruit Company will offer special post convention trips to Havana, Cuba. One itinerary will call for a round trip, New Orleans to Havana and return, while another itinerary will be from New Orleans to Havana and thence to New York. Information concerning these trips is as follows:

TRIP NO. 1

New Orleans to Havana and return to New Orleans—post-convention trip—all-expense-included plan

Leave New Orleans	ss. *Iriona*	Jan. 2	NOON
Arrive Havana	" "	" 4	A. M.

(Stop over Hotel Ritz or Bristol—room with private bath and meals included)

Leave Havana	ss. *Cartago*	Jan. 10— 9	A. M.
Arrive New Orleans	" "	" 11	P. M.

(Interesting auto trips, etc., can be arranged in Havana at very moderate cost and will be arranged for those members who desire that such trips be arranged for them)

The fares for the above trip, which also include the hotel stop in Havana with meals, will be:

Beds in cabins without private bath on steamer—
$100.00 to $106.00 each person

Beds in cabins with private bath on steamer—
$116.00 each person

Beds in suites with private bath on steamer—
$150.00 each person

TRIP NO. 2

New Orleans to Havana, thence Havana to New York

Leave New Orleans	ss. *Iriona*	Jan. 2	NOON
Arrive Havana	" "	" 4	A. M.

(Stop over Hotel Ritz or Bristol—room with private bath and meals included)

Leave Havana	ss. *Toloa*	Jan. 7 1	A. M.
Arrive New York	" "	" 10	A. M.

(Different auto trips, etc., can be arranged while in Havana at very low cost)

The fares for the above trip, including hotel stay in Havana with meals, will be:

Beds in cabins without private bath on steamer—
$135.00 to $143.00 each person

Beds in cabins with private bath on steamer—
$157.00 each person

Beds in suites with private bath on steamer—
$203.00 each person

TRANSPORTATION TO AND FROM NEW ORLEANS

A special section of the Piedmont Limited will leave Boston on Saturday, December 26, at 12:00 noon. This train will be called the American Association for the Advancement of Science Special, and passengers will be limited to scientists and their friends and relatives. Eastern members of the executive committee are expected to use this train and to meet for informal discussion of association business. Extra cars are expected to be added at New York, Philadelphia, Washington, Greensboro and Atlanta. An itinerary showing roads, times of departure, etc., follows:

December	26	Lv. Boston	NYNH&H	12:00 NOON
"	"	Lv. New Haven	"	3:35 P. M.
"	"	Ar. Washington	PRR	10:05 P. M.
December	26	Lv. New York	PRR	6:45 P. M.
"	"	Lv. Trenton	"	8:03 P. M.
"	"	Lv. W. Phila.	"	8:44 P. M.
"	"	Lv. Baltimore	"	10:43 P. M.
"	"	Ar. Washington	"	11:38 P. M.
December	26	Lv. Washington	Sou. Rwy.	11:55 P. M.
"	27	Lv. Charlottesville	"	2:55 A. M.
"	"	Lv. Greensboro	"	7:30 A. M.
"	"	Ar. Atlanta	"	4:00 P. M.
"	28	Ar. New Orleans	L&N	7:20 A. M.

It is hoped that western and central railroads will also arrange for special trains.

For many of those planning to attend the New Orleans meeting of the association, from December 28, 1931, to January 2, 1932, there will be a choice of two kinds of reduced railway fares: (1) on the standard certificate form and (2) short limit round trip winter excursion fares.

(1) Reduced railway rates, by the standard certificate plan, have been granted by all the railway passenger associations in the United States and by the eastern lines of the Canadian Passenger Association, but a few companies, listed below, have not granted reduced rates. The round-trip fare by this plan is one and one-half times the regular one-way fare.

Tickets to New Orleans by the standard certificate plan are to be purchased within time limits as follows: December 21 to 27, inclusive, for Canadian Eastern lines, Central lines and Trunk lines. For New England lines, December 20 to 26, inclusive. For Southeastern lines, December 22 to 28, inclusive. For Western and Transcontinental lines the inclusive dates are December 18 to 24 from California; December 19 to 25, from Arizona, British Columbia, Idaho, Montana, Nevada, Utah, Washington and Oregon (except *via* California); December 17 to 24 from Oregon (*via* California); December 20 to 26 from New Mexico, Wyoming and Colorado (except Julesburg); December 21 to 27 from Julesburg, Colorado, and from Illinois, Iowa, Kansas, Manitoba, Minnesota, Missouri, Nebraska, northern Michigan, North Dakota, South Dakota and Wisconsin. For the Southwestern lines the inclusive dates are December 20 to 26 from Oklahoma and Texas and December 21 to 27 from Arkansas, Kansas, Louisiana and Missouri; also Memphis, Tenn., and Natchez, Miss.

The following Southwestern lines do not offer reduced fares on the certificate plan: Arkansas and Louisiana Missouri Railway, Fort Smith and Western Railroad, Graysonia, Nashville and Ashdown Railroad, Missouri and North Arkansas Railway, Oklahoma City-Ada-Atoka Railway, Wichita Falls and Southern Railway, Kansas, Oklahoma and Gulf Railway, National Railways of Mexico and the Midland Valley Railway.

Persons residing in the regions of reduced rates (almost all the United States and Canada) should each purchase a first-class, full-fare, one way, through ticket to New Orleans, being sure to secure a certificate on "Standard Certificate Form," reading for the "New Orleans meeting of the American Association for the Advancement of Science and Associated Societies." A receipt is not required and will not be useful.

Persons residing outside the regions of reduced rates should each purchase a round-trip ticket to the nearest station issuing through tickets to New Orleans and situated within the region of reduced rates. On arrival at that station a one-way ticket to New Orleans and a certificate, as directed in the preceding paragraph, should be secured.

Every one should register immediately upon arrival at New Orleans, at the registration offices for the meeting, in the Roosevelt Hotel. Be sure to fill in all blanks on the registration card and leave the card at the registration desk, where you will receive a numbered identification card, which will be receipted for the registration fee paid. (See Registration, below.) Then leave your railway certificate at the validation desk, being sure that the identification card (which you keep) is there marked to show that you have deposited a certificate. Your certificate will subsequently be endorsed by the association and then validated by the agent of the transportation companies. Call for it later at the validation desk, where you left it, presenting your identification card.

Unvalidated certificates will not be honored for the purchase of return tickets and unendorsed certificates can not be validated. Registration is therefore necessary in order to have a railway certificate validated. Each person registering is entitled to the validation of his own certificate.

For the return trip, railway agents at New Orleans will honor any properly endorsed and validated cer-

tificate if presented at least thirty minutes before the scheduled time of departure of the train for which it is to be used. Each person presenting an endorsed and validated certificate may purchase a continuous-passage, one-way, return ticket for one half of the regular fare, by the same route as that followed on the trip to New Orleans. Certificates may be validated from December 28, 1931, to January 1, 1932. The last date on which return tickets may be purchased is January 5.

(2) Short limit round-trip winter excursion rates are available from many points in the United States to destinations in Alabama, Florida, Louisiana and Mississippi, and also to Havana, Cuba. These rates have been granted for only certain days in November and December, 1931, and March and April, 1932. During December, 1931, round-trip excursion tickets to New Orleans may be purchased on the following days: 4, 5, 6, 11, 12, 13, 18, 19, 20, 25, 26 and 27. Tickets are limited to 16 days, including date of purchase and actual time required to return to starting-point. The following is a comparison of the cost under the two plans of a round-trip ticket (not including Pullman berth) from Washington, D. C., to New Orleans:

Standard Certificate form (one and one-half fares)	$60.30
Short limit round-trip winter tourist rate	54.30

It is advisable to get information from your local ticket agent about the excursion fares, since there are some points where they are not available. The Canadian eastern lines and the Transcontinental lines are among those that are not authorizing these fares.

CHARLES F. ROOS,
Permanent Secretary

SCIENTIFIC APPARATUS AND LABORATORY METHODS

A METHOD OF SUPPLYING STUDENTS WITH NATURAL ENDAMOEBA HISTOLYTICA FROM CULTURES[1]

INSTRUCTORS in protozoology are not always fortunate enough to have an active case of amoebic dysentery available for use in the classroom. Cultures of *Endamoeba histolytica* are commonly used, but the amoebae in culture are much smaller[2] than those encountered in the amoebic stool. It would seem desirable to be able at any time to supply large amoebae and these should also contain red blood cells.

In the course of some experimental studies, irrelevant to the present subject, it was found that the addition of gum arabic to produce a 0.1 per cent. solution in the liquid portion of the ordinary Boeck and Drbohlav medium[3] resulted in a marked increase in the size and number of the amoebae usually present. Further investigation disclosed that the increase in size was probably related to the bacteriostatic action of the gum arabic. As a matter of fact some of the bacteria commonly found in association with the amoebae in culture were not only inhibited but were killed by the use of gum arabic in stronger percentages. The increase in size of the amoebae led one competent observer to remark; "That is the nearest thing to *histolytica* in the stool I have ever noted in cultures."[4] The amoebae, although increased in size, are somewhat slowed in action by the increased viscosity of the fluid.

Usually the addition of red blood cells to cultures of *Endamoeba histolytica* results in the hemolysis of the cells very quickly, with the result that if the cells are ingested only shadows of the cells can be seen within the amoeba. Furthermore, the amoebae, in my experience, seldom ingest the red blood cells under these conditions. In the course of certain immunological studies involving the amoebae, it was found that successful efforts to cause them to ingest red blood cells resulted from the use of the following technique:

Mix the medium well by rotating the culture tubes between the palms of the hands. Combine the liquid portion of ten cultures so treated, place in 10 cc centrifuge tubes and centrifuge at 1,000 r.p.m. for ten minutes. Discard the supernatant liquid, combine the sediment, and add two to five cc of rabbit serum. Mix well with a pipette and add 0.1 cc of guinea-pig or rabbit red blood cells. The latter are obtained by defibrination and centrifugalization. Again centrifuge at 1,000 r.p.m. for ten minutes and place in the water bath for two hours. At the end of this period many of the amoebae will be found to have ingested the cells; some will contain a large number; twenty or more cells may be found within them. The preparations made from sediment were found to be satisfactory up to at least six hours; after this time the cells begin to hemolyse and the amoebae to disappear.

Enlarged amoebae containing red blood cells, resulting from the technique described, yield very pretty specimens for class work and give students a better

[1] From the laboratories of the Army Medical School, Washington, D. C.

[2] J. H. St. John, American Journal of Tropical Medicine, 6, 319. 1926.

[3] W. C. Boeck and J. Drbohlav, *Proc. Natl. Acad. Sci.* no. 5, Washington, 1925; *Amer. Jour. Trop. Hyg.*, 5, 371.

[4] Colonel Charles F. Craig, Medical Corps, U. S. Army.

idea of *Endamoeba histolytica,* as found in infections, than is conveyed by the use of ordinary cultures of this parasite.

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PHOTOGRAPHING ANIMALS

THE scientific photographer often has trouble getting animals in a suitable position. Small animals are very active and will not stay long enough in a pose to be photographed successfully. We tried out a method for quieting snakes and lizards and it gave good results.

The photographs were made at night with Eastman flash paper, and the animals remained still in spite of the flash. The animal to be photographed was placed under an inverted box for a minute or two until all signs of commotion had ceased. The box was lifted quickly but smoothly, the flash-paper was ignited and the film was exposed. This method was also tried in broad daylight with lizards, snakes and rats, and gave good results with all the animals tried. This simple method may be good when the animal has to be moved to certain surroundings and resents it. Evidently the swift change from total darkness to a sudden glare leaves the animal dazed for a moment and gives time for the exposure.

ARTHUR L. KAHN
GEO. H. HANLEY

SPECIAL ARTICLES

ACCELERATED INFECTION IN EXPERIMENTAL POLIOMYELITIS

THE 1931 epidemic of poliomyelitis will enable investigators to study by experimental means, in monkeys, many aspects of the disease, as well as the virus inducing it. The establishment of strains of the human virus in monkeys is attended by initial difficulties which it is desirable to overcome. The experience of the past indicates that a proportion only of human strains can be implanted on the monkey. *Macacus rhesus* is the species which has been commonly employed for inoculation. It has not infrequently happened that after the first successful inoculation of monkeys with human spinal cord or medulla obtained from fatal cases of poliomyelitis, the succeeding inoculation of the spinal cord of the affected monkey has failed to induce disease. The reason for this disparity is not known. It is supposed that degeneration or virus metabolic products contained in the human cord act to make the originally inoculated monkey more susceptible to infection.

A way has been found to increase the proportion of successful inoculations of affected human and monkey spinal cords and brain stems. A number of years ago, Amoss and I observed that an attenuated strain of the monkey virus, unsuccessful on first inoculation, could be made to induce infection by repetition of the injection. We have recently employed this method in implanting 1931 human strains of virus on *Macacus rhesus* monkeys. The method consists in injecting intracerebrally and intraperitoneally, under ether anesthesia, 10 per cent. suspensions of glycerolated spinal cord. The suspensions should be free from bacteria as shown by aerobic plate tests. In our experience thus far, symptoms have either not appeared at all in from 7 to 10 days, or initial symptoms, slight in degree, have arisen and have failed to progress or have disappeared. The effects, if any occurred, tended therefore to the production of the abortive form of experimental poliomyelitis.

Time was allowed to elapse in order to determine whether the symptoms would progress or recede. As no increase occurred, reinoculation was resorted to with material from the same subjects as was employed for the original injection. Again the double—intracerebral and intraperitoneal—inoculations were made, using of course the opposite side of the brain. The symptoms which were stationary or receding were rapidly augmented; and about three days after the second injection the symptoms became pronounced, progressing quickly to paralysis and prostration, as is the rule with infected monkeys.

Not only can the abortive be converted into the progressive paralytic disease by means of reinoculation, but monkeys which develop no detectable symptoms in 11 or 12 days have been successfully infected through the employment of a second injection. The critical period seems to be about three days after the second injection. Within this brief period an accelerated reaction occurs. Whether the acceleration is due to virus alone, or in part to the alien (human) tissue elements, is not known. It may be merely a summation of virus effects, such as Amoss and I observed with monkey strains of virus. The results as described are not invariable. In one or two instances the accelerated effect either failed to arise or was delayed.

The tests to determine whether the reinoculation method suffices to establish durably in monkeys many strains of human poliomyelitis virus have yet to be completed. It remains also to be seen whether highly potent virus strains adapted to monkeys can be readily secured in this manner.

The histological changes present in the spinal cord

and the basal and intervertebral ganglia of the reinoculated animals are typical of experimental poliomyelitis.

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THE RING STRUCTURE OF ADENOSINE

ADENOSINE is an adenine glycoside of d-ribose. As in the case of other glycosides, this particular one may exist in two forms isomeric with regard to their ring structure.

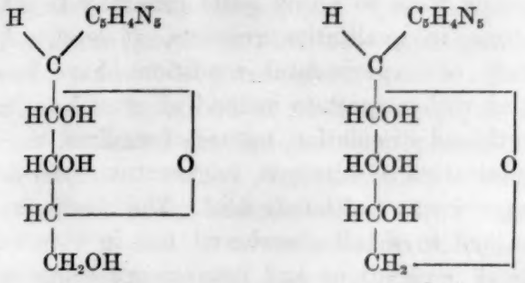

Fig. I represents the furanoside and Fig. II the pyranoside structure. It has now been established that natural adenosine possesses the furanoside structure. This information is important in connection with the theory of the structure of nucleic acids, of which a detailed discussion will be given elsewhere.

The structure was established through the complete methylation of the nucleoside. By hydrolysis of the methylated nucleoside a trimethyl ribose differing from 2, 3, 4-trimethyl ribose has been obtained and to the new sugar is attributed the furanose structure. The points of difference are:

(1) The physical state at room temperature; the substance from the nucleoside being a liquid whereas 2, 3, 4-trimethyl ribose is crystalline.

(2) The optical rotation; that of the new substance being $[\alpha]_D^{26} = +51.6°$ and that of the corresponding pyranose $[\alpha]_D^{27} = -51.7°$.

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ALARIA MUSTELAE SP. NOV., A TREMATODE REQUIRING FOUR HOSTS

AN undescribed trematode of the superfamily, Strigeoidea, occurring in the intestines of wild minks and weasels of Michigan, is of particular interest because it requires four hosts for the completion of its life history and its hermaphroditic adult stage is preceded by a series of three larval stages, cercaria, agamodistomum and metacercaria.

The cercaria resembles in many respects *Cercaria marcianae* Cort and Brooks, 1928, but differs from the latter in its smaller size, its simpler excretory system which consists of five flame cells in the body and two in the tail stem on each side, the spination which is restricted to the anterior portion of the body, the possession of only a single row of spines around the opening of the acetabulum, and by the position of the four penetration glands, two on either side of the ventral sucker. The further development of the cercaria is much like that of *C. marcianae* for it also penetrates frogs and tadpoles, in which it undergoes some growth and development. It also retains many of its cercarial characters after entering its first vertebrate host so that it is similar to *Agamodistomum marcianae* from which it can be distinguished, however, by the same characters which differentiate the cercariae of the two species. When these agamodistomes were fed to laboratory raised rats and mice, they underwent further growth and development becoming fully developed metacercariae of the diplostomulum type in the muscles. Similar metacercariae were found as natural infections in the muscles and lungs of the mink and raccoon, and in the muscles of the white-footed deer-mouse.

Experimentally infected laboratory mice were fed to a parasite-free ferret, and ten days later full grown Alaria were found in the intestines. Metacercariae from lungs of minks when fed to dogs, cats and ferrets also developed into Alaria. The worms raised experimentally in all these hosts agree in all characters including measurements with those found in the intestines of wild weasels and minks.

Experiments to get cercariae to penetrate directly into mice were unsuccessful, proving that the stage occurring in frogs and tadpoles is an essential step in the life cycle of this parasite. *Alaria mustelae* passes through the following stages and hosts in order to complete its life history; sporocysts in the snail, producing cercariae, which penetrate into tadpoles or frogs in which they become agamodistoma; these when eaten by a mammal, such as a mink, raccoon or mouse, become metacercariae in the muscles or lungs; metacercariae grow to adult state when eaten by another mammal such as a mink, weasel, cat, dog or ferret, in the intestines of which they deposit their eggs. From the latter, miracidia hatch, which are capable of infecting the snail.

Many metacercariae in all stages of development were secured from lungs of mink, making it possible to follow the development of the reserve excretory system and the reproductive system. The reserve

excretory system arises as an outgrowth from the primary excretory bladder, the branches of which secondarily anastomose to form the network of vessels and spaces characteristic of the adults of the superfamily Strigeoidea. All the organs of the reproductive system are completely formed in the metacercaria but in a less mature state than in the adult.

Alaria mustelae, sp. nov.: characters of the genus. Length 0.82–1.74 mm, foliaceous forebody one to two times length of the cylindrical hindbody, entirely covered with retrorse spines. Oral sucker terminal, average width and length 0.082 x 0.082 mm, slightly larger than acetabulum, but shorter than pharynx, which averages 0.106 x 0.078 mm; ovary anterior to testes, averaging 0.152 mm in width; Mehlis' gland postero-lateral to anterior testis; uterine eggs few, averaging 0.11 x 0.072 mm. Cercaria fork-tailed, pharyngeate, flame cell pattern 2[(1+1+1)+(1+1+(2))], developing in slender unbranched sporocysts in the snail, *Planorbula armigera*. Agamodistomum stage in frogs and tadpoles. Metacercariae of diplostomulum type, in muscles and lungs of small frog-eating mammals.

Poche, 1925, split up the family Strigeidae Railliet, separating off the family *Cyathocotylidae* with *Cyathocotyle* Mühling as the type genus. It is here proposed to restrict the family Strigeidae still further by removing all those forms not belonging within the subfamily *Strigeinae* Railliet. The genus *Brauninа* Heider becomes the type of the family *Brauninidae* fam. nov., which is characterized by the great reduction of the hindbody, by the inclusion within the holdfast organ of all reproductive organs except terminal portions of genital ducts, and the possession of cirrus and cirrus-pouch. The genus *Alaria* Schrank is the type of the family *Alariidae* Tubangui, 1922, which includes the subfamilies *Alariinae* Hall and Wigdor, and *Polycotylinae* Monticelli. The genus *Cleistogamia* Faust is removed from the superfamily *Strigeoidea* since it does not have a holdfast organ, and possesses several characters not found within the superfamily *Strigeoidea*. These characters are those structures which make the cleistogamous type of fertilization imperative and the nonoperculate egg with filamentous appendages. The genus Cleistogamia Faust is placed in a new family *Cleistogamiidae* with the single subfamily *Cleistogamiinae* Faust, 1927. No suggestion is offered regarding its relationship to other families.

A more complete description of this parasite, its life history, and a discussion of the taxonomy of the Strigeoidea will appear elsewhere.

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THE RELATION BETWEEN IRON, HUMIC ACID AND ORGANIC MATTER IN THE NUTRITION AND STIMULATION OF PLANT GROWTH

THIS communication will report briefly an extensive investigation just concluded in which the chemical substance contained in natural soil humic acid, chiefly responsible for the marked stimulation of growth of various higher and lower plants, has been determined. The growth studies have been conducted with the free-living aerobic soil bacterium *Azotobacter vinelandii*, and, although the findings apply strictly to this organism only, there are numerous reasons for believing them to apply quite generally to other organisms, in qualitative respects, at least. A wide variety of experimental conditions have been employed with respect to method of growth, criteria of growth and stimulation, nature of medium, source and concentration of nitrogen, temperature, pH, duration of experiment and humic acid. The results are being described in detail elsewhere,[1] but in view of their general implications and interest are being summarized here.

Both natural soil humic acids and synthetic humic acids have been employed. The former were prepared by washing soil with N HCl and then extracting with 10 per cent. KOH, the latter by boiling 20 per cent. glucose in 35 per cent. HCl and then centrifuging and extracting with 10 per cent. KOH. Purification was accomplished in both cases by precipitating at pH 3, centrifuging, and redissolving at pH 7.5, the cycle being repeated five times in all. It was possible to prepare, by minor variations in method and soil used, natural humic acids varying in iron content from 0.06 to 1.4 per cent. By adding $Fe_2(SO_4)_3$ to the glucose-HCl mixture during boiling, it was possible to prepare synthetic humic acids varying in iron content from 0.03 to 4.4 per cent.; other metals could be introduced similarly into the synthetic humic acids.

It has been determined that natural humic acid increases growth primarily, if not entirely, by virtue of the *iron* it contains; the organic fraction is substantially inactive, and likewise other inorganic impurities. The following evidence supports this finding.

(a) Natural humic acid may be substituted more

[1] "The Chemical Nature of Humic Acid Growth Stimulation in Relation to Iron" and "The Physiological Nature of Humic Acid Stimulation of *Azotobacter* Growth," submitted for publication to *Soil Science*. These papers contain some seventy-five tables and figures of experimental data and represent several thousand experimental cultures. The relation of the present investigation to previous similar ones will not be discussed here, beyond mentioning the following recent pertinent papers: Clark, SCIENCE, 71, 269 (1930); Hopkins, *Bot. Gaz.*, 89, 209 (1930); Olsen, Compt. rend. Lab. Carlsberg, 18, 1 (1930); Iwasaki, *Bioch. Zeit.*, 226, 32 (1930); Blumenberg and Blumenberg, U. S. Patent 1,783,694, Dec. 2 (1930); Farries and Bell, *Ann. Bot.*, 44, 424 (1930); and Ashby, *Ann. Bot.*, 43, 805 (1929).

or less satisfactorily by complex non-ionized iron combined with an organic acid, such as ferric citrate, tartrate, oxalate; by inorganic ionic iron such as ferric sulfate, metallic iron; and by synthetic humic acids containing considerable percentages of iron. In any given experiment there may be a certain variability in response to the four different iron types, depending upon the particular nature of the experiment, and inevitable secondary differences between the types. A statistical study of the mass of data available shows, however, that *a given amount of soluble iron gives the same order of stimulation independently of whether the iron is added as in natural humic acid or as in any of its substitution compounds.* This statement is made with the provision that the experiments be allowed to proceed long enough to permit complete physiological consumption of the iron added, so as to avoid any limitation through induction period differences as described below. Iron stimulation may be observed often upon addition of as little as 0.01 p.p.m. Fe. The minimum concentration yielding approximately optimum stimulation, however, is about 0.5 p.p.m., under conditions where significant decreases in the iron concentrations being studied do not occur during the period of measurement. As the iron is later consumed in growth, as a function of time, the minimum optimum concentration of initially added iron may shift to as high as 5 to 10 to 15 p.p.m., causing 5 to 20-fold increases in growth. As a corollary to these quantitative relations, it may be stated that, as the percentage of iron contained in a compound increases, so stimulation increases, for any given concentration of natural or synthetic humic acid, or organic acid, iron compound. In considering inorganic iron it is important to observe that, although the last three types of compounds are completely soluble, inorganic iron is soluble in the majority of neutral media to the extent of only 0.01 to 0.05 p.p.m., which is considerably below the minimum optimum concentration of about 0.5 p.p.m. Owing to this solubility limitation inorganic iron will often yield, especially in experiments of relatively short duration, less satisfactory stimulation than the other three types, when comparison is made upon the basis, not of soluble iron, but of total iron added to the medium.

(b) Natural humic acid was not substituted by humic acids prepared synthetically from glucose to contain no more than traces of iron; by iron-free synthetic humic acids containing various metals such as Al, Co, Mn, Si, Mo and P; or by salts of such elements as Al, Co, Mn, Mo, Ni, Zn, Cr, Cu and Ag, at various concentrations ranging from 0.01 to 50 p.p.m.

(c) Both natural humic acid and all compounds capable of substituting for it show an induction period, measurable in terms of hours, before stimulation is exerted.

(d) Humic acid does not act by increasing directly the availability of constituents normally added to, or present in, the medium, *viz.*, glucose, oxygen, free or fixed nitrogen, carbon dioxide, Ca, Mg, Na, K, Fe, PO_4, Cl, SO_4, HCO_3; or by deactivating toxic metabolic products; or by affecting the surface tension, viscosity, potential differences between culture medium and organism, or oxidation-reduction potential of the medium.

(e) Under conditions where humic acid exerted no stimulative effect the iron substitution compounds likewise exerted no effect, even though other chemical substances and physiological conditions could at the same time increase the growth considerably.

The only observed inherent difference between various types of iron compounds obtains with respect to the physiological induction period. In the case of *Azotobacter,* natural and synthetic humic acids ordinarily commence to exert stimulation 3 to 8 hours after addition, organic acid iron compounds after 8 to 15 hours, and inorganic iron compounds after 15 to 30 hours. Natural and synthetic humic acids are to be classed, therefore, as stimulants which provide iron for growth and nutrition in a form *more highly available* than that generally supplied in media. They are more highly available than organic acid iron compounds by virtue of induction period differences; than inorganic iron by virtue of both induction period differences and solubility relations. They may also be classed as nutrients, since, as pointed out above, when time is not a limiting factor, the same quantitative order of stimulation is obtained independently of iron compound type. Humic acids are not plant vitamins or any other constituents classifiable as essential to growth or nutrition, since they may be replaced by other substances containing iron.

It is realized that various humic acids, prepared from various soils or sugars and metals under various conditions might, contrary to our findings with *Azotobacter,* occasionally exert stimulation from various causes in addition to that of contained iron, *e.g.,* from contained aluminum, silica, phosphate, etc.; by adding a protective agent against poisons; by increasing the availability of medium constituents; or by adding a specific, stimulating, purely organic substance. It is conceivable, for instance, that some organism being studied might possess a special requirement for, say aluminum, in which case a natural or synthetic humic acid containing aluminum impurity might very well act by virtue of supplying aluminum, instead of, or in addition to, iron. So far as we are aware, no comprehensive, critical data obtain in favor of any of these suggested causes.

On the other hand, iron contained in humic acid may promote other processes besides growth. Many

biological processes, such as respiration, nitrification, catalase activity, etc., probably require iron. We have recently determined that apart from its essential function in both the growth and respiration of *Azotobacter*, iron is also essential in the chemical mechanism of nitrogen fixation by this organism. Under certain conditions of relative iron starvation, natural or synthetic iron-containing humic acids may supply this iron, replacing the more customarily supplied inorganic or organic iron compounds. In this sense the humic acids may be said to influence directly the mechanism of fixation. Under ordinary conditions, humic acids have no such direct influence, but exert the same quantitative stimulation whether the organisms are grown in free or in various forms of fixed nitrogen.

In conclusion, a few of the implications of these findings, apart from their relation to respiration, growth, and nitrogen fixation by *Azotobacter*, may be mentioned. There are undoubtedly fifty or more different plant and animal growth stimulators described in the literature, such as bios, yeast water, plant extracts of various kinds, organic extracts, peat extracts, soil extracts, auximones, egg albumen, egg extract, Rhizopin, vitamin B and possibly other vitamins, in which the chemical reason for stimulation is in practically no case known. Humic acid is thus probably one of the few growth promoters of which the chemical constitution of the active constituent has been definitely determined. It is possible that many, perhaps the majority, of the promoters consist substantially of iron bound in an organic, highly available form, since their action appears to be very similar to that of humic acid; indeed, it may be suggested that the real problem in connection with the chemical nature of the active fraction of these promoters would perhaps more often be to show that they do *not* function chiefly because of contained iron. Many media, *viz.*, legume nodule bacteria media, stock culture media, are made up to contain yeast water, plant extracts, egg extract, or bios, of complicated and relatively unknown general composition; the use of humic acids, particularly synthetic ones, would perhaps often provide desirable substitutes in some degree avoiding this objectionable feature. It is probable, for instance, that the recent yeast-growth stimulant prepared by Fulmer, Williams, and Werkman[2] in the sterilization of synthetic yeast medium at elevated temperatures is similar to our synthetic humic acids, the iron being derived from the probable 1 p.p.m. iron impurity contained in the 5 per cent. sucrose employed.

It is possible that iron added as humic acid to water cultures of higher green plants would upon occasion be superior to most of the forms of iron now employed, especially in the matter of requiring much less frequent addition. Whereas inorganic iron compounds tend in general to precipitate as the pH is increased, the converse obtains with respect to humic acid, above pH 4. Even compounds like ferric citrate precipitate in neutral solutions, upon long standing, whereas properly prepared humic acids remain soluble indefinitely. Many higher plants grown in water cultures must be maintained under relatively acid conditions, in order to derive sufficient iron from the forms usually supplied; the use of humic acid might permit satisfactory or improved growth under substantially neutral or alkaline conditions.

The nutritional value of humus and soil organic matter in agricultural cropping is recognized generally, being ascribed, however, chiefly to indirect effects upon soil moisture, texture, aeration, etc. How far the nutritional value is directly referable to rendering iron more available, particularly in soils in which the inorganic iron solubility is low, is an important problem of agricultural science which would appear to be in some measure enlarged by the present investigations. It is our hope, in view of the fact that the latter have been concerned solely with *Azotobacter*, that the general problem of the influence of natural and synthetic humic acids upon the growth and nutrition of higher plants under field and water culture conditions will receive the attention of plant physiologists equipped to deal with the question.

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[2] *J. Bact.*, 21, 299, 1931.

BOOKS RECEIVED

BRITISH MUSEUM OF NATURAL HISTORY. *Guide to the Exhibition Galleries.* Pp. x + 249. Illustrated. 1s. *Short History of Collections.* Pp. xi + 62. 6d. *Guide to Exhibition Illustrating the Early History of Paleontology.* Pp. vi + 68. Illustrated. 9d. The Museum.

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